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USERS MANUAL FOR THE SIMULATION TIME HISTORY AND ACCESS TIME HISTORY PROGRAMS

by
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CARDEROCKDIV/SHD-1297-01 USERS MANUAL FOR THE TIME HISTORY AND ACCESS TIME HISTORY PROGRAMS

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The Simulation Time History Computer Program, STH, has been developed at the Carderock Division of the Naval Surface Warfare Center to provide realistic, random wave time histories of the six-degree-of-freedom (6DOF) ship responses, i.e., surge, sway, heave, roll,pitch, and yaw. The 6DOF "origin" time histories are developed using transfer functions obtained from the Navy Standard Ship Motion Computer Program, SMP84. The random waves are simulated using a two-parameter Bretschneider wave spectral model. The random waves are represented as either undirectional (longcrested) or spread ± 90 degrees about a predominant direction (shortcrested).

A separate Access Time History Computer Program, ACTH, has been developed to provide additional displacements, velocities, and accelerations at various locations on the ship . Force time histories, which include gravity, are computed in the ship's body axis coordinate system. The ACTH program utilizes the origin time histories generated from the STH program. (continued)

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The computer programs, STH and ACTH, are written in FORTRAN 77. The response time histories are written from the ACTH program in binary format but can optionally be written instead in an ASCII format for ease in transferring between computers.

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ABBREVIATIONS AND SYMBOLS

A	Constant used in Bretschneider spectrum
ACTH	Access time history computer program
ASCII	American National Standard Code for Information Exchange
B	Constant used in Bretschneider spectrum; Square root of cosine-squared weighting constant used for shortcrested time histories
B^2	Cosine-squared weighting constant used for shortcrested sea spectrum
DAT	Extension used for time history data files
DOS	Disk operating system used for personal computers
EL_O, EL_A, EL_V	Longitudinal, lateral, and vertical displacements in the earth reference system
EXE	Extension used for executable files
FL_O, FL_A, FL_V	Longitudinal, lateral, and vertical forces in the earth reference system
g	Gravitational acceleration
INP	Extension used for input files
K	Wave number
LC	Longcrested
LCG	Longitudinal center of gravity referenced from the Forward Perpendicular
M_{ij}	Angular rotation matrix element
Mbyte	Megabyte
MHz	Megahertz
MII	Motion-induced interruption
MS-DOS	Microsoft Disk Operating System
PC	Personal computer
rps	Radians per second
RSV	Response statistical value
S_ζ	Wave spectral density
S_{LO}, S_{LA}, S_{LV}	Longitudinal, lateral, and vertical forces in the ship reference system
SC	Shortcrested

ABBREVIATIONS AND SYMBOLS (Continued)

SMP	Navy Standard Ship Motion Program
SMP81	1981 version of the Navy Standard Ship Motion Program
SMP84	1984 version of the Navy Standard Ship Motion Program
STH	Simulation time history computer program
t	Time
TEX	Extension used for text files
THACP	Time History Access Program used for the non-aviation ship motion data base
T_0	Modal wave period
x^*, y^*, z^*	x,y,z coordinates of any point on the ship, referenced to the origin at the LCG
6DOF	Six-degrees-of-freedom ship motions (surge, sway, heave, roll, pitch, and yaw)
γ	Random phase angle used to develop wave and ship response time histories
ϵ_{Pk}	Phase angle between ship response and wave elevation at the origin
ζ, ζ_A	Wave and wave amplitude
ζ^*	Wave at a point location on the ship
$(\zeta_W)_{1/3}$	Significant wave height
θ	Pitch angle
μ	Ship heading angle; Predominant wave direction with respect to the sea for shortcrested seas
ν	Component of wave direction with respect to the ship for shortcrested seas
σ	Standard deviation
ϕ	Roll angle
ψ	Yaw angle
χ	Wave direction relative to predominant wave direction
ω	Wave frequency in radians per second
ω_E	Encountered wave frequency

ABSTRACT

The Simulation Time History Computer Program, STH, has been developed at the Carderock Division of the Naval Surface Warfare Center to provide realistic, random wave time histories of the six-degree-of-freedom (6DOF) ship responses, i.e., surge, sway, heave, roll, pitch, and yaw. The 6DOF "origin" time histories are developed using transfer functions obtained from the Navy Standard Ship Motion Computer Program, SMP84. The random waves are simulated using a two-parameter Bretschneider wave spectral model. The random waves are represented as either unidirectional (longcrested) or spread ± 90 degrees about a predominant direction (shortcrested).

A separate Access Time History Computer Program, ACTH, has also been developed to provide additional displacements, velocities, and accelerations at various locations on the ship. Force time histories, which include gravity, are computed in the ship's body axis coordinate system. The ACTH program utilizes the origin time histories generated from the STH program.

The computer programs, STH and ACTH, are written in FORTRAN 77. The response time histories are written from the ACTH program in binary format but can optionally be written instead in an ASCII format for ease in transferring between computers.

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INTRODUCTION

In 1981, CARDEROCKDIV* documented and released a frequency domain ship motion prediction program called the Navy Standard Ship Motion Program, SMP81.[1] This computer program, and the subsequently updated version, SMP84,[2] calculates the translational and angular ship statistical responses in irregular (random) seas.

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* formerly the David Taylor Research Center (DTRC).

Although originally encompassed within the scope of the SMP developmental work, response time history generation has never been formally documented as a computer tool. In 1976, using the theory and equations from References 3 and 4, a longcrested, origin time domain data base was assembled for a set of destroyers and frigates. This data base, in turn, could be accessed and manipulated to obtain either longcrested or shortcrested response time histories via the Time History Access Program, THACP[5]. This report will provide the software and documentation for generating origin time histories and a new access program for utilizing them to obtain additional response time histories.

The need for a time domain versus a frequency domain methodology lies in the phase relationship between ship motions. Frequency domain analysis eliminates the phasing information while developing a universe of single amplitude, statistical answers for ship responses over a range of ship headings, ship speeds, and modal wave periods at specific wave heights. Frequency domain answers, such as those predicted in SMP84, are independent, earth-referenced, absolute or relative displacements, velocities, and accelerations at various locations on the ship.

On the other hand, time domain analysis retains the phasing of one motion with respect to another. Thus a data base of origin time histories can be operated upon at any point in time to obtain additional response time histories at various locations on the ship. It also allows for the translation from an earth-referenced system to a ship-referenced system whereby the forces on an object on the ship can be determined. This is required when evaluating forces, apparent in the ship's body axis coordinate system, due to the component of gravity contributed by angular displacements.

Applications for using time domain data are many and varied. For example, ship motion time histories can be

- o input to flight simulators for launch and recovery of aircraft on moving decks;
- o used for determining forces/effects on equipment, aircraft, munitions[6], or anything on or in the ship;

- o utilized for human factors considerations and the occurrence of Motion-Induced Interruptions (MII)[7];
- o helpful in developing/evaluating limitations on shipboard systems.

The remainder of this report is divided into four major sections:

Theoretical Background - a description of the theory used to develop ship response time histories in random waves. Expressions are provided to obtain responses at various locations on the ship. The transformation from earth coordinate system to ship coordinate system for forces is described.

Computer System - a description of the hardware and software used in the development/execution of the programs;

Simulation Time History Program, STH - a description of the program used to generate wave time histories and associated six-degree-of-freedom (origin) ship response time histories. Input and output for the STH program is discussed. An example of running the STH program is provided; and

Access Time History Program, ACTH - a description of the program used to compute ship response time histories at various locations on the ship from the data base of STH origin motion time histories. Input and output for the ACTH program is discussed. An example of running the ACTH program is provided.

This manual was written with the intention of providing simple, easy-to-use methods for generating ship response time histories in random seas. A necessary requirement is the availability of SMP84 Origin transfer functions for specific ships. Although time histories can be used for a wide range of purposes and each user's need may be different, careful reading and understanding of the illustrated examples is considered the fastest method for learning how to utilize the software tools.

THEORETICAL BACKGROUND

The theory necessary to develop ship response time histories in random seas is outlined in the following sections. These response

time histories are generated using regular wave response transfer functions obtained from the Navy Standard Ship Motion Program, SMP.[1,2] A basic set of six response time histories is generated at the longitudinal center of gravity of the ship by the Simulation Time History Program, STH. This base set of time histories is then used to generate response time histories at other locations on the ship by the Access Time History Program, ACTH.

SHIP RESPONSES IN REGULAR WAVES

There are a basic set of six ship responses (surge, sway, heave, roll, pitch, and yaw) at the ship's longitudinal center of gravity (LCG) from which motions at all other locations on the ship can be developed. These responses are referred to as the six degrees of freedom (6DOF).

The strip theory of Salvesen, Tuck, and Faltinsen[8] is used to obtain the 6DOF responses for a ship advancing at constant forward speed with arbitrary heading in regular sinusoidal waves of unit amplitude. The theory of Reference 8 is implemented in the Navy Standard Ship Motion Computer Program SMP81[1] and the subsequently updated version, SMP84.[2]

The 6DOF responses are assumed to be small, linear, and harmonic with respect to a wave whose maximum elevation is located at the origin of the x,y,z coordinate system shown in Fig. 1. This right-handed coordinate system is moving at the constant mean forward speed with the origin lying in the undisturbed free surface and located at the LCG.

It should be noted that a ship advancing through regular waves responds to the wave frequency of encounter given by,

$$\omega_E = \left| \omega - (\omega^2 V/g) \cos(\mu) \right| \qquad (1)$$

where V is the mean forward speed of the ship, μ is the heading angle, and ω is the wave frequency. The absolute value is taken to avoid using negative encounter frequencies. The definition of heading angle is shown in Fig. 2 for waves advancing from the

starboard side of the ship.

Although the 6DOF ship responses are assumed to be linear, experiments with ship models in regular waves, as reported in Reference 6, show that the roll response exhibits nonlinear behavior with increasing wave amplitude. In addition, the experiments of Reference 9 show that the roll damping coefficient of the equations of motion at the natural roll frequency tend to be nonlinear with increasing roll angle. This nonlinear behavior of roll is treated in SMP[1,2] through modifications made to the roll damping coefficient which is assumed to be a function of mean roll angle. SMP computes the lateral responses (sway, roll, and yaw) for a set of eight mean roll angles, 0.5, 1, 2.5, 5, 10, 15, 25, and 40 degrees.

The 6DOF ship responses to regular sine waves are defined as ship origin transfer functions which vary with wave frequency, ship speed, ship heading relative to the waves, and, in the case of the lateral responses, mean roll angle. The SMP84 program outputs a file of the 6DOF origin transfer functions (amplitude and phase) with respect to regular waves called the Origin file. This file is used to provide a data base of transfer functions which are used in the generation of time histories of ship responses in random seas which is discussed in a latter section.

SHIP RESPONSES IN RANDOM SEAS

The SMP84 program principally predicts the translational and angular ship statistical responses in random (irregular) seas using calculations performed in the frequency domain. Two basic assumptions are used in making ship motion predictions in random seas[10], namely:

1. The random sea waves can be represented as a sum of simple sine waves whose amplitudes are obtained from specified wave spectral densities and whose phases are random with a uniform distribution; and

2. The responses of a ship to the random sea waves can be obtained as the sum of the ship responses to the individual sine waves that compose the random sea.

The instantaneous wave elevations of the random seas have a narrow-banded Gaussian distribution with zero mean. The wave single amplitudes (1/2 the peak to trough values) have a Rayleigh distribution.

The responses of the ship in random seas represent a linear tranformation applied to the Gaussian random waves. Thus the instantaneous ship responses are assumed to be Gaussian with zero mean and the ship response single amplitudes are assumed to have a Rayleigh distribution.

Table 1 provides a set of single amplitude Rayleigh statistical constants which can be applied to either a wave or ship response standard deviation to obtain estimates of various amplitudes such as the average of the one-third highest amplitudes (significant value), the highest expected amplitude in 200 cycles, etc.

The roll single amplitudes are assumed to have an underlying Rayleigh distribution which is modified by the nonlinear behavior of roll damping with increasing roll amplitude. SMP84 provides roll predictions in random seas for a user-specified Rayleigh statistic, such as significant single amplitude, see Table 1, and a specified significant wave height (average of the one-third highest wave double amplitudes). The user is referred to the SMP81 user's manual[1] for more details concerning the method used to obtain roll predictions in random seas.

SEAWAY DESCRIPTION

A two-parameter Bretschneider wave spectral model is used to define the frequency content of the random sea waves. The two parameters are, by definition, significant wave height, $(\zeta_W)_{1/3}$, and modal (peak) wave period, T_O. The wave spectral density, $S_\zeta(\omega)$, is defined as:

$$S_\zeta(\omega) = A\omega^{-5} \cdot \exp(-B\omega^{-4}) \qquad \text{in } m^2\cdot s \text{ or } ft^2\cdot s \quad , \qquad (2)$$

where,

$$A = 487.0626 \cdot (\zeta_W)_{1/3}/T_O \qquad \text{in } m^2\cdot s \text{ or } ft^2\cdot s \quad , \text{ and} \qquad (3)$$

$$B = 1948.2444/T_O^4 \qquad \text{in } s^{-4} \quad , \tag{4}$$

and ω is the wave frequency in radians per second.

It should be noted that the area under the spectrum is equal to the variance or mean square value of the waves. The square root of the variance is called the standard deviation. The significant wave height is defined as four times the standard deviation. The wave spectral shape is a function of the modal wave period. Examples of the wave spectra are shown in Fig. 3 for modal wave periods of 7, 11 and 21 seconds. Note that the same significant wave height value of 12 feet is used for each of the three wave spectra shown.

The distribution of wave spectral energy as a function of heading with respect to the ship is considered either to be unidirectional (longcrested) or spread $\pm$ 90 degrees about a predominant direction (shortcrested). The shortcrested wave spectral density, $S_\zeta(\omega,\nu)$, is defined as:

$$S_\zeta(\omega,\nu) = B^2(\nu-\mu) \cdot S_\zeta(\omega) \quad , \tag{5}$$

where $S_\zeta(\omega)$ is the longcrested wave spectral density defined in Eq. 2. The cosine-squared spreading function, B^2, used to spread the wave energy from longcrested to shortcrested seas, is defined as:

$$B^2(\nu-\mu) = (2/\pi) \cdot \cos^2 (\nu-\mu) \quad . \tag{6}$$

The heading μ in the case of shortcrested seas represents the predominant heading containing the principal amount of wave energy. The heading angle ν represents one of the component heading angles.

SMP84 uses a 15-degree heading increment to define ν. Thus, there are thirteen component headings, six on either side of the predominant heading angle. The cosine-squared spreading function for each of these component headings is:

$$B_k^2 = (2/\pi)\int_{\chi_k - d\chi/2}^{\chi_k + d\chi/2} \cos^2 (\chi_k) d\chi \quad , \tag{7}$$

where $\chi_k = \nu_k - \mu$ is the wave direction relative to the predominant direction. Thus,

$$B_k^2 = 1/6 \cos^2 (\chi_k) \quad , \tag{8}$$

where $\chi_k = k\pi/12$, $k = -6,6$.

An example of the shortcresting method is shown in Fig. 4 for an output predominant heading angle of 45 degrees. Note that the heading convention for computational work in SMP84, as defined in Fig. 2, defines 180 degrees to be head seas, 90 degrees as starboard beam seas, and zero degrees as following seas. The heading angles presented in the SMP84 output however differ from the internal computational heading angle by 180 degrees, i.e.,

$$\mu_{output} = 180 - \mu_{computational} \quad . \tag{9}$$

Thus, for output purposes, zero degrees represents head seas, 90 degrees represents starboard beam seas (unchanged), and 180 degrees represents following seas. This output heading convention was selected to bring consistency between program output and conventions employed by the ship and aircraft operator communities.

DEFINITION OF TIME HISTORIES

Time histories in random seas are defined as time series sampled at equal time intervals for a period of time sufficiently long to provide stable statistical results. Typically this time duration is 15 minutes or longer. These time histories contain approximately 100 cycles which have varying amplitudes and periods. The amplitudes follow a Rayleigh distribution.

Wave Time Histories at the Origin

Time histories of encountered waves located at the origin of the fixed earth coordinate system which is moving at constant mean forward speed are computed for either longcrested or shortcrested seas using the method of Zarnick[3].

The longcrested (unidirectional) wave time history, $\zeta_{LC}(t)$, is defined as:

$$\zeta_{LC}(t) = \sum_{k=1}^{N} \{ \ (\zeta_k) \ \cos \ (\omega_{Ek} t + \gamma_k) \ \} \quad , \tag{10}$$

where ω_{Ek} is the encountered wave frequency defined in Eq. 1 for wave frequency ω_k and γ_k is a random phase angle with uniform distribution at wave frequency ω_k.

The wave amplitude, ζ_k, at wave frequency ω_k is defined as

$$\zeta_k = [\ 2 \int_{\omega_k - d\omega/2}^{\omega_k + d\omega/2} S_\zeta(\omega) \, d\omega \ ]^{1/2} \quad , \tag{11}$$

where $S_\zeta(\omega)$ is the wave spectral density defined in Eq. 2.

The number of frequencies, N, used to compute the wave time history should be large in order to obtain an representative Rayleigh distribution of single amplitudes. The value of N used in the Simulation Time History Program, STH, is 150.

The range of wave frequencies is determined in SMP84 when the origin transfer function file is generated. The frequency increment used to generate the wave time history is:

$$d\omega = (\omega_{max} - \omega_{min}) / (N-1) \quad , \tag{12}$$

where ω_{max} and ω_{min} are the maximum and minimum wave frequencies used

in SMP84 for a particular ship. SMP84 uses different values for ω_{max} depending on the ship's roll period.

For most headings and ship speeds, the encounter frequencies computed by Eq. 1 and used in Eq. 10 are incommensurate. This is an important requirement which prevents the longcrested time histories from repeating after a period of time. This requirement is violated in beam seas or for a ship speed of zero knots. For this situation, the wave frequencies are adjusted slightly using a random frequency increment to guarantee that they are incommensurate as:

$$\omega_k = \omega_k - (d\omega/2) \cdot (1 - 2 \cdot RAND_k) \tag{13}$$

where $RAND_k$ is a random number selected at frequency ω_k with a value between 0 and 1 and which has a uniform distribution.

The shortcrested sea condition spreads the wave directions ± 90 degrees from a predominant wave direction relative to the ship. The shortcrested wave time history, $\zeta_{SC}(t)$, is defined as:

$$\zeta_{SC}(t) = \sum_{j=1}^{M} \sum_{k=1}^{N} \{ (b_j \cdot \zeta_k) \cos (\omega_{Ek}t + \gamma_{jk}) \} , \tag{14}$$

where b_j is a factor for angular spreading of the wave energy (assumed independent of wave frequency). A cosine-squared function is used to spread the wave energy from longcrested to shortcrested seas, i.e.,

$$b_j = \{ (2/\pi) \int_{X_j - d\ /2}^{X_j + dX/2} \cos^2 (X_j) dX \}^{1/2} , \tag{15}$$

where X_j is the wave direction relative to the predominant direction.

Origin Motion Time Histories

Time histories of ship responses to longcrested seas, $r_{LC}(t)$, are defined as:

$$r_{LC}(t) = \sum_{k}^{N} \{ (R_{Ak} \cdot \zeta_k) \cos (\omega_{Ek} t + \gamma_k + \epsilon_{Pk}) \} , \tag{16}$$

where R_{Ak} is the amplitude of the ship response transfer function at the wave frequency of encounter, ω_{Ek}. The phase angles ϵ_{Pk} refer to the phase of the ship response with respect to the maximum elevation at the origin of the x,y,z coordinate system shown in Fig. 1.

Note that velocities and accelerations of the ship responses computed in the ACTH program are obtained by digital differentiation in the time domain.

Motions at a Point Time Histories

The translational displacement time histories of any point on the ship (x^*, y^*, z^*) are obtained as

$$\begin{aligned} EL_O(t) = x(t) &- y^* \sin \psi(t) + z^* \sin \theta(t) \\ &+ x^* [\cos \psi(t) + \cos \theta(t) - 2] , \end{aligned} \tag{17}$$

$$\begin{aligned} EL_A(t) = y(t) &- z^* \sin \phi(t) + x^* \sin \psi(t) \\ &+ y^* [\cos \phi(t) + \cos \psi(t) - 2] , \end{aligned} \tag{18}$$

$$\begin{aligned} EL_V(t) = z(t) &- x^* \sin \theta(t) + y^* \sin \phi(t) \\ &+ z^* [\cos \theta(t) + \cos \phi(t) - 2] , \end{aligned} \tag{19}$$

where EL_O, EL_A, and EL_V are the ship displacements in the longitudinal, lateral, and vertical directions, and x, y, z, ϕ, θ, and ψ are surge, sway, heave, roll, pitch, and yaw, respectively.

Wave Time Histories at a Point

Time histories of encountered waves at any point on the ship

(x^*, y^*) in longcrested seas are obtained as:

$$\zeta^*_{LC}(t) = \sum_{k=1}^{N} \{ \zeta_k \cos [\omega_{Ek} t - K(x^* \cos \mu + y^* \sin \mu) + \gamma_k] \} \quad , \qquad (20)$$

where K is the wave number defined as $K = \omega^2/g$, and μ is the computational heading angle.

Encountered wave time histories at point (x^*, y^*) in shortcrested seas are obtained as:

$$\zeta^*_{SC}(t) = \sum_{j=1}^{M} \sum_{k=1}^{N} \{ (b_j \cdot \zeta_k) \cos [\omega_{Ejk} t - K(x^* \cos \mu_j + y^* \sin \mu_j) + \gamma_{jk}] \} \quad . \qquad (21)$$

<u>Relative Motion Time Histories</u>

The relative motion of any point on the ship (x^*, y^*) is represented by:

$$RM(t) = EL_V(t) - \zeta^*(t) \quad , \qquad (22)$$

where EL_V is the absolute vertical displacement and ζ^* is the undisturbed wave elevation at that point.

<u>Ship System Force Time Histories</u>

There are two types of forces applied to a body at any point (x^*, y^*, z^*) on the ship. The first type consists of the inertia forces due to the accelerations of the ship and the second type is due to the acceleration of gravity. No friction forces or wind drag forces are computed in the Access Time History Program, ACTH.

The forces per unit mass in the fixed earth coordinate system are defined as

$$FL_O(t) = -EL_{\ddot{O}}(t) \quad , \tag{23}$$
$$FL_A(t) = -EL_{\ddot{A}}(t) \quad , \tag{24}$$
$$FL_V(t) = -EL_{\ddot{V}}(t) - 1 \quad , \tag{25}$$

where $EL_{\ddot{O}}$, $EL_{\ddot{A}}$, and $EL_{\ddot{V}}$ are the earth system accelerations in the longitudinal, lateral, and vertical directions, and 1 represents the acceleration due to gravity (i.e., 1g). Note that the inertia forces are the negative of the ship accelerations.

The forces are more appropriately applied in the ship coordinate system where the longitudinal and lateral forces are parallel to the deck and the vertical force is normal to the deck. The ship system force time histories are obtained from the fixed Earth axis forces using an angular rotation matrix as:

$$\begin{bmatrix} SL_O(t) \\ SL_A(t) \\ SL_V(t) \end{bmatrix} = \begin{bmatrix} M_{11}(t) & M_{12}(t) & M_{13}(t) \\ M_{21}(t) & M_{22}(t) & M_{23}(t) \\ M_{31}(t) & M_{32}(t) & M_{33}(t) \end{bmatrix} \cdot \begin{bmatrix} FL_O(t) \\ FL_A(t) \\ FL_V(t) \end{bmatrix} , \tag{26}$$

where SL_O and SL_A are the ship system forces in the longitudinal and lateral directions parallel to the deck, and SL_V is the ship system force normal to the deck. The angular rotation matrix elements M_{ij} are defined as:

$$M_{11}(t) = \cos\theta(t) \cos\psi(t) \quad , \tag{27}$$
$$M_{12}(t) = \cos\theta(t) \sin\psi(t) \quad , \tag{28}$$
$$M_{13}(t) = -\sin\theta(t) \quad , \tag{29}$$
$$M_{21}(t) = -\cos\phi(t) \sin\psi(t) + \sin\phi(t) \sin\theta(t) \cos\psi(t) \quad , \tag{30}$$
$$M_{22}(t) = \cos\phi(t) \cos\psi(t) + \sin\phi(t) \sin\theta(t) \sin\psi(t) \quad , \tag{31}$$
$$M_{23}(t) = \sin\phi(t) \cos\theta(t) \quad , \tag{32}$$
$$M_{31}(t) = \sin\phi(t) \sin\psi(t) + \cos\phi(t) \sin\theta(t) \cos\psi(t) \quad , \tag{33}$$
$$M_{32}(t) = -\sin\phi(t) \cos\psi(t) + \cos\phi(t) \sin\theta(t) \sin\psi(t) \quad , \tag{34}$$
$$M_{33}(t) = \cos\phi(t) \cos\theta(t) \quad , \tag{35}$$

where the rotation is in the order of first yaw, then pitch, and finally roll.

COMPUTER SYSTEM

The Simulation Time History Program, STH, and the Access Time History Computer Program, ACTH, were developed on a COMPAQ 386 Personal Computer (PC) running at a machine clock speed of 20 MHz. This computer is compatible with the IBM Personal Computers. The operating system used was Microsoft Disk Operating System (MS-DOS), Version 3.31.[11] The computer had an INTEL 80387 co-processor installed to provide increased speed for floating point calculations.

Both the STH and ACTH programs were written in FORTRAN 77 using the Lahey Fortran Compiler.[12] The only special compiler option used was to make integer and logical variables four bytes each. The IBM Link program provided with the MS-DOS operating system was used to link the compiled versions of the STH and ACTH programs to obtain executable program files.

The STH and ACTH programs use a large number of files when they are executed. Fortunately, MS-DOS supports the use of directories, paths, and file names and extensions which allow the user to organize these files in a meaningful way. Generally, PC's are purchased with hard disks having a minimum capacity of 21 Mbytes. The MS-DOS operating system allows you to easily divide a hard disk into subsections called directories. Each directory is given its own unique name by the user. A path is defined as the series of commands and directions to the particular section of the disk or directory where a particular set of files is stored. Each file can have a name containing up to eight characters and an extension containing up to three characters.

The organization of directories and files used to develop the STH and ACTH programs is shown in Fig. 5. Files in this figure are denoted by extensions (e.g., .EXE) while directories and subdirectories carry no extensions. Details concerning the specific files used by the STH and ACTH programs are discussed in the latter sections of this report which describe these programs.

The hard disk on the COMPAQ 386 where these programs were developed had a 42-Mbyte capacity which was divided into two parts called volumes or drives in MS-DOS, each with a 21-Mbyte capacity. Each volume has its own drive letter where C is the drive letter for the first 21-Mbyte section and D is the drive letter for the second 21-Mbyte section. The first directory on a drive is called the ROOT directory. All other directories on the drive are called subdirectories. Note that subdirectories may also contain their own subdirectories. Refer to the COMPAQ MS-DOS Reference Guide[11] to obtain further information about directories and file naming conventions.

SIMULATION TIME HISTORY PROGRAM, STH

The Simulation Time History Program, STH, was developed to provide a data base of six-degrees-of-freedom (6DOF) ship response time histories (surge, sway, heave, roll, pitch, and yaw) in longcrested and shortcrested random seas. The STH program uses a file of 6DOF origin transfer functions output from the Navy Standard Ship Motion Program, SMP84, to generate the 6DOF ship response time histories. This 6DOF time history data base is then used by the Access Time History Program, ACTH, which is described in a later section of this report, to generate time histories for additional ship responses at various user-specified locations on the ship. The STH program takes a long time to execute, approximately 43 minutes for a 20-minute simulation run done at 3 samples per second. By contrast, the ACTH program executes very quickly, approximately 22 seconds to use the same 20-minute STH run to generate additional time histories.

In order to run the STH program you will need to set up various directories on your hard disk(s) to contain the executable program file, input files, and output time history files for the STH program. An example of this setup is shown in Fig. 5. The STH executable file, identified by the "EXE" extension, and input file, identified by the "INP" extension, are contained in the STH directory on the C drive. The STH output files, identified by the "DAT" and "TEX"

extensions, are located on the D drive in a subdirectory called "SODD965A" under a directory called "STHDATA". The example ship name used for running the STH program is the "DD965" which is part of the subdirectory name. The letters "SO" in the subdirectory name are fixed and are shorthand for "simulation time history at the origin". The letter "A" following the ship name identifies a hull variant. A summary of files used by the STH program is provided in Table 2.

SMP84 will output different origin transfer functions depending on whether a ship is untrimmed, trimmed, has a different appendage suite, uses passive fins or active fin stabilization, etc. These variations of the same ship are called hull variants and are assigned different variant letters, A, B, C, etc. The SMP84 origin transfer function file for variant A of the DD965 ship, identified by the "ORG" extension, is located on the D drive in a subdirectory called "DD965" under a directory called "SMPDATA".

Both the STH and ACTH programs were designed to run in a BATCH mode. The information required to run each program is contained in a text file with an "INP" extension in the STH directory which the user edits using a screen editor (not provided) prior to running the programs. Both progams can then generate a number of origin or response time histories during one execution and thus may be left to run overnight. There are commercially available programs for PCs that allow multi-tasking which would allow the STH and ACTH programs to run in the background during the day. Note that the ACTH program requires origin time histories previously generated by the STH program.

STH INPUT DESCRIPTION

The input required to run the STH program is contained in a text (ASCII) file called STH.INP in the STH directory. There are 10 sets of information, called Data Sets, contained in this file. Each data set may contain one or more lines of information. The method used to describe each data set is to list each line, its FORTRAN format, and the variable(s) contained on it. A summary of the 10 STH data sets is provided in Table 3. An example of the STH.INP file is provided

in Table 4. Note that comments may be added to the STH.INP input file after Data Set 10 to provide assistance in identifying the information on each data set when making changes.

Data Set 1, SMP Data Path

One Line - Format (A)

(1) SMPDATAS, alphanumeric, columns 1-80, path indicating where the SMP84 origin transfer function file can be found.

Data Set 2, STH Data Path

One Line - Format (A)

(1) STHDATAS, alphanumeric, columns 1-80, path indicating where the origin time history files output from the STH program will be saved.

Data Set 3, Ship Type

One Line - Format (A)

(1) SHIPTYPS, alphanumeric, columns 1-8, identifies ship type.

A convention used when running SMP84 is to identify each ship by its type. This name is used as a directory name where the SMP84 input files for ships of this type are stored.

Data Set 4, Ship Name

One Line - Format (A)

(1) SHIPS, alphanumeric, columns 1-5, identifies ship name.

Data Set 5, Hull Variant

One Line - Format (A)

(1) VARIANTS, alphanumeric, column 1, identifies hull variant.

The hull variant is used to distinguish between different SMP84 origin transfer function files which may have been generated for the same ship. For example the ship may have been run in SMP84 for different displacements, trims, appendage suites, or passive/active fin stabilizers.

Data Set 6, Cycle No

One Line - Format (A)

(1) CYCLES, alphanumeric, columns 1-2, cycle number.

A cyle number is assigned to the SMP84 input and text output files when SMP84 is run for a given ship. This cycle number is not assigned however to SMP84 data files, specifically the origin transfer function file.

Data Set 7, Units

One Line - Format (A)

(1) SUNITS, alphanumeric, columns 1-6, the desired displacement time history engineering units (feet or meters).

SMP84 can be run for a given ship using either feet or meters. The user can specify the engineering units to be used for the STH origin time histories which will overide the units used in the SMP84 run. Only the displacement motions, surge, sway, and heave, are affected by the selection of different units. Note that the units identified in this data set apply to the information contained in the succeeding data sets for the STH program as well as the data sets for the ACTH program.

Data Set 8, Title

One Line - Format (A)

(1) TRIALS, alphanumeric, columns 1-40, the ship title.

Data Set 9, Wave Point Input

First Line - FORMAT (A)

No variables, blank line used for spacing.

Second Line - Format (18X,I5)

(1) NWPOINT, integer, columns 19-23, number of wave points.

NWPOINT is set to zero if you do not want to compute relative motion time histories in the ACTH program. Note, however, that if relative motion is desired at a later date, the user must rerun the STH program and include the wave points where the relative motion is to be computed. Lines 3-5 are always included even if NWPOINT=0.

Third Line - FORMAT (A)

No variables, blank line used for spacing.

Fourth Line - FORMAT (A)

No variables, comment used to identify wave point table.

Fifth Line - FORMAT (A)

No variables, comment identifies columns for wave point table.

NOTE: The next line is included only if NWPOINT > 0. There is one line for each wave point.

Sixth Line - Format (I4,3F8.1,3X,A20)

(1) IWPNT, integer, columns 1-4, wave point number.

(2) WPNTXLOC, floating point, columns 5-12, x-coordinate of wave point (station number, where 0=Forward Perpendicular).

(3) WPNTYLOC, floating point, columns 13-20, y-coordinate of wave point (positive to port from centerline).

(4) WPNTZLOC, floating point, columns 21-28, z-coordinate of wave point (positive up from baseline).

(5) WPTNAMES, alphanumeric, columns 29-48, the name of the wave point.

The reference system used to input locations on the ship in the STH and ACTH programs is shown in Fig. 6. This input reference system is identical to the input system used in the Navy Standard Ship Motion program, SMP81.[1]

Data Set 10, Run Input

First Line - FORMAT (A)

No variables, blank line used for spacing.

Second Line - Free Format

(1) NRUNS, integer, number of STH runs

NOTE: The next line is repeated for each STH run.

Third Line - Free Format (variables separated by commas)

(1) RUNNUMBER, integer, the run number.

(2) SAMPLERATE, floating point, number of samples per second.

(3) TSTART, floating point, start time in seconds.

(4) TEND, floating point, stop time in seconds.

(5) SPEED, floating point, ship speed in knots.

(6) HEAD, floating point, SMP output heading in degrees. (0°=head seas, 90°=beam seas, 180°=following seas)

(7) SIGWH, floating point, significant wave height in feet or meters.

(8) TMODAL, floating point, modal wave period in seconds.

(9) STATIS, floating point, statistic used for roll iteration in irregular seas. For example, the statistic used for the significant roll single amplitude is 2 (twice the standard deviation for roll).

(10) SEATYPES, alphanumeric, seaway type. The seaway type is identified as LC (longcrested seas) or SC (shortcrested seas). The seaway type can be enclosed in double quotes but it is not necessary.

The selection of sample rate affects the resolution of the STH time histories as well as the amount of computer time required to run the STH program. For the majority of runs it is recommended that a sample rate of 2 samples per second be used. However, for high speeds in bow to head seas, encounter periods as low as one second or less may be computed which will require increasing the sample rate to 3 samples per second to avoid frequency aliasing.

STH OUTPUT DESCRIPTION

Information describing each STH run is displayed on the computer's screen. This information consists of:

1. STH program identification;
2. Date and time;
3. Ship identification and particulars, which include desired engineering units (feet or meters), gravity, ship length, longitudinal center of gravity, LCG, (referenced from the Forward Perpendicular), and the distance from the ship baseline to the waterline;
4. STH run identification which includes run number, comment, and sample rate. The run conditions are identified, which include ship speed, heading, seaway type (longcrested or shortcrested), significant wave height, modal wave period,

the statistic used for roll iteration, and the number of channels;

5. Listing of wave point locations (required for relative motion calculations in the ACTH program);
6. Listing of first 20 seconds of wave height at the LCG and the six degree of freedom responses (surge, sway, heave, roll, pitch, and yaw); [Note that the time histories for wave height at wave point locations are computed (optionally) but not shown on the screen. The screen is then blanked out until the run finishes]
7. Listing of the statistical results obtained from the time histories for wave height (LCG), the 6DOF responses, and wave heights at wave point locations; [These statistics include the mean, standard deviation, maximum and minimum values for each channel. The frequency domain predictions for the standard deviation for each channel are provided in the last column.]
8. The elapsed computer time for the particular STH run.

The information displayed on the screen is saved in a text (ASCII) file for each run. This file is called SRN.TEX where N is the run number. The SRN.TEX file is stored in a ship subdirectory under the STHDATA directory, e.g., D:\STHDATA\SODD965A. An example of this file for STH run number 3 is shown in Table 5.

The STH time histories are written to a standard FORTRAN sequential binary data file called SRN.DAT which is stored in the same subdirectory as the SRN.TEX file. The first record in this file contains two integer variables, the total number of samples and the number of channels. The remaining records, one for each sample, contain the time histories for all the channels in the desired engineering units.

A separate text file called STHLOG.TEX is updated for each run. This file contains a summary of the STH runs that have been made. The summary consists of a separate line for each run that contains the run number, data format type (binary), simulation run time in minutes, DATE-TIME-GROUP (day, hour, minute, L(local), month, and

year), and the run comment. The run comment shows the seaway type, ship speed, heading angle, significant wave height, and modal wave period. An example of the STHLOG.TEX file is shown in Table 6. The STHLOG.TEX file is stored in the same subdirectory as the SRN.TEX and SRN.DAT files.

ACCESS TIME HISTORY PROGRAM, ACTH

The ACTH program uses (origin) time histories generated by the STH program to generate response time histories for a given ship at various locations on the ship. The STH time histories for various ships are located in ship subdirectories under the STHDATA directory. The ACTH program uses the STH data path described above to locate the STH time histories. For example, the STH data path shown in Fig. 5 is D:\STHDATA\SODD965A where D is the drive letter, STHDATA is the STH data directory, and SODD965A is the ship subdirectory for the DD965 ship.

The ACTH response time histories for various ships are located in ship subdirectories under the ACTHDATA directory. For example, the ACTH data path shown in Fig. 5 is D:\ACTHDATA\SPDD965A where the letters SP are the abbreviation for simulation response time histories at various locations on the ship. A summary of files used by the ACTH program is provided in Table 7.

ACTH INPUT DESCRIPTION

The information required to run the ACTH program is contained in a file called ACTH.INP located in the STH directory. This information is organized into 10 Data Sets described below and summarized in Table 8. An example of the ACTH.INP file is provided in Table 9.

Data Set 1, STH Data Path

One Line, Format (A)

(1) STHDATAS, alphanumeric, columns 1-80, path indicating where the origin time history files output from the STH program are located.

Data Set 2. ACTH Data Path

One line - Format (A)

(1) ACTHDATAS, alphanumeric, columns 1-80, path indicating where the ACTH response time histories will be saved.

Data Set 3. Ship Name

One Line, Format (A)

(1) SHIPS, alphanumeric, columns 1-5, identifies ship name.

Data Set 4. Output Data Format

One line, Format (7X,I5)

(1) ASCII, integer, columns 8-12, specifies data format to be used for the ACTH response time histories. Use 1 for binary output format and 2 for ASCII output format.

The ACTH response time histories are saved in either a binary format or an ASCII format. The default format is binary. The ASCII format is useful for transferring these time histories to other computers via either a modem or magnetic disks. Note that the ASCII format uses more storage (bytes) than the binary format and takes longer to write.

Data Set 5. Wave Point Input

First Line - FORMAT (A)

No variables, blank line used for spacing.

Second Line - Format (18X,I5)

(1) NWPOINT, integer, columns 19-23, number of wave points.

NWPOINT is set to zero if you do not want to compute relative motion time histories in the ACTH program. Note, however, that if relative motion is desired at a later date, the user must rerun the STH program and include the wave points where the relative motion is to be computed. Lines 3-5 are always included even if NWPOINT=0.

Third Line - FORMAT (A)

No variables, blank line used for spacing.

Fourth Line - FORMAT (A)

No variables, comment used to identify wave point table.

Fifth Line - FORMAT (A)

No variables, comment identifies columns for wave point table.

NOTE: The next line is included only if NWPOINT>0. There is one line for each wave point.

Sixth Line - Format (I4,3F8.1,3X,A20)

(1) IWPNT, integer, columns 1-4, wave point number.

(2) WPNTXLOC, floating point, columns 5-12, x-coordinate of wave point (station number, 0=Forward Perpendicular).

(3) WPNTYLOC, floating point, columns 13-20, y-coordinate of wave point (positive to port from centerline).

(4) WPNTZLOC, floating point, columns 21-28, z-coordinate of wave point (positive up from baseline).

(5) WPTNAMES, alphanumeric, columns 29-48, the name of the wave point.

Wave point locations are required to be input only if relative motion time histories are desired. Wave time histories at these points must have been previously generated by the STH program. The same wave point locations should have been used in the STH input. The ACTH program compares the wave point locations used in the ACTH and STH input and stops if they are not identical.

Data Set 6, Point Input

First Line - FORMAT (A)

No variables, blank line used for spacing.

Second Line - Format (13X,I5)

(1) NPOINT, integer, columns 14-18, number of points on the ship where response time histories are computed.

NPOINT is set to zero if you do not want to compute response time histories at a point. Lines 3-5 are always included even if NPOINT=0.

Third Line - FORMAT (A)

No variables, blank line used for spacing.

Fourth Line - FORMAT (A)

No variables, comment used to identify point table.

Fifth Line - FORMAT (A)

No variables, comment used to identify columns for point table.

NOTE: The next line is included only if NPOINT>0. There is one line for each wave point.

Sixth Line - Format (I4,3F8.1,3X,A20)

(1) IPNT, integer, columns 1-4, point number.

(2) PNTXLOC, floating point, columns 5-12, x-coordinate of point (station number, 0=Forward Perpendicular).

(3) PNTYLOC, floating point, columns 13-20, y-coordinate of point (positive to port from centerline).

(4) PNTZLOC, floating point, columns 21-28, z-coordinate of point (positive up from baseline).

(5) PNTNAMES, alphanumeric, columns 32-51, the name of the point.

Data Set 7. Channel Input

First Line - FORMAT (A)

No variables, blank line used for spacing.

Second Line - Format (15X,I5)

(1) NCHAN, integer, columns 16-20, number of channels.

Third Line - FORMAT (A)

No variables, blank line used for spacing.

Fourth Line - FORMAT (A)

No variables, comment used to identify channel table.

Fifth Line - FORMAT (A)

No variables, comment used to identify columns for channel table. There is one line for each channel.

Sixth Line - Free Format

(1) ICHN, integer, channel number.

(2) IRSP, integer, response number.

1 = surge; longitudinal response at a point (earth system); longitudinal force at a point (ship system)

2 = sway; lateral response at a point (earth system); lateral force at a point (ship system)

3 = heave; vertical response at a point (earth system); vertical force at a point (ship system)

4 = roll; relative motion at a point (earth system)

5 = pitch

6 = yaw

7 = wave height at the origin or at a wave point location.

(3) ITYP, integer, response type.

1 = displacement

2 = velocity

3 = acceleration

4 = angle

(4) ISYS, integer, response system.

1 = earth system

2 = ship system

(5) IPNT, integer, response point number from Data Set 5 or 6.

The method used to select the ACTH channels is outlined in Table 10. Each channel is defined by five numbers; channel number, response number, response type number, reference system desired, and point location. The first step is to select a point number. If the point number is zero, the response numbers are limited to 1-6 for the 6DOF reponses and 7 for wave height at the LCG. Only the earth reference is allowed. Displacement, velocity, or acceleration (types 1,2,3, respectively) are allowed for any of these responses.

If user selects a point number greater than zero, then both earth and ship reference systems are allowed. The available response numbers for the earth system are 1-3 corresponding to longitudinal, lateral, and vertical responses at a point, 4 for relative motion at a wave point, and 7 for wave height at a wave point. Displacement, velocity, or acceleration (types 1,2,3, respectively) are allowed for any of these responses. If the user selects the ship reference system, then the response numbers allowed are 1-3 for the longitudinal, lateral, and vertical forces at a point. The response type is restricted to 3 which is acceleration (force per unit mass).

Data Set 8. Start ACTH Run

First Line - FORMAT (A)

No variables, blank line used for spacing.

Second Line - Format (15X,I5)

(1) STARTRUN, integer, columns 16-20, start ACTH run number.

Data Set 9. No of ACTH Runs

One Line - Format (16X,I5)

(1) NRUNS, integer, columns 17-21, number of ACTH runs

Data Set 10. STH Run Input

First Line - FORMAT (A)

No variables, blank line used for spacing.

Second Line - FORMAT (A)

No variables, comment used to identify STH run input.

There is one line for each STH run.

Third Line - Free Format

(1) STHRUN, integer, STH (origin) time history run number.

ACTH OUTPUT DESCRIPTION

The ACTH program only displays three items on the screen for each run; the ACTH program identification, the total number of ACTH runs to be made, and the run that the ACTH program is currently working on. An example of the ACTH screen display is provided in Table 11.

The information describing each ACTH run is written to a text file called ARM.TEX where M is the run number. The ARM.TEX file is stored in a ship subdirectory under the ACTHDATA directory, e.g., D:\ACTHDATA\SPDD965A. An example of this file for ACTH run number 3 is shown in Table 12. The ARM.TEX file is comparable to the SRN.TEX file written by the STH program. The information contained in the ARM.TEX file consists of:

1. DATE-TIME-GROUP;
2. Ship identification;
3. ACTH run identification which includes run number, comment,

sample rate, and run times (the corresponding STH run number is identified);

4. Ship particulars;
5. Run particulars including ship speed, heading, sea type, etc.;
6. Table of STH statistical results which compares time domain and frequency domain calculations of the standard deviation for the STH channels;
7. Listing of wave point locations (required for relative motion calculations in the ACTH program);
8. Listing of point locations (required for motions, velocities and accelerations at a point and forces in the ship system);
9. Listing of channels and there associated points (the channel number, name, type, unit, system, and the point number and the point location associated with the channel are also given);
10. Listing of the statistical results obtained from the ACTH time histories (these statistics include the mean, standard deviation, maximum and minimum values for each ACTH channel);
11. The total number of samples for the run.

The ACTH time histories are written in one of two possible formats depending on the value of the variable ASCII in Data SET 2 of the ACTH input. If the user chooses ASCII=1, then the time histories are written to a standard FORTRAN sequential binary data file called ARM.DAT. The first record in the file contains two integer variables, the total number of samples and the number of channels. The remaining records, one for each sample, contain the time histories for all the ACTH channels in the desired engineering units. The ARM.DAT file is stored in the same subdirectory as the ARM.TEX file.

If the user instead chooses ASCII=2, then the time histories are written to a formatted FORTRAN sequential ASCII data file called ARM.ASC as:

Record 1. Header

One Line - Format (2I5)

(1) COUNT, integer, columns 1-5, total number of samples.

(2) NCHAN, integer, columns 6-10, number of channels.

Records 2-(COUNT+1). ACTH time history data

Line 1 - Format (2I5,8F8.3)

(1) CNT, integer, columns 1-5, sample number.

(2) KL, integer, column 10, line number (set to 1).

(3) ACTHDATA, floating point, columns 11-18, 19-26, etc., up to eight channels of ACTH time histories at sample CNT. The time histories are in engineering units.

A second line is required if there are more than eight channels.

Line 2 - Format (5X,I5,8F8.3)

(1) No variable, first 5 columns skipped.

(2) KL, integer, column 10, line number (set to 2).

(3) ACTHDATA, floating point, columns 11-18, 19-26, etc., remaining channels of ACTH time histories at sample CNT.

An example of the ARM.ASC file is shown in Table 13. The ARM.ASC file is stored in the same subdirectory as the ARM.TEX file.

A separate text file called ACTHLOG.TEX is updated for each run. This file contains a summary of the ACTH runs that have been made. The summary consists of a separate line for each run that contains the ACTH run number, data format type (binary or ASCII), simulation run time in minutes, DATE-TIME-GROUP (day, hour, minute, L(local), month, and year), and the run comment. The run comment shows the seaway type, ship speed, heading angle, significant wave height, and modal wave period. An example of the ACTHLOG.TEX file is shown in Table 14. The ACTHLOG.TEX file is stored in the same subdirectory as the ARM.TEX file.

There is also a file called ERROR.TEX that is created when the ACTH program is executed. This formatted sequential file contains any error messages that may have occurred while the program was executing. A message telling the user that all STH runs were successfully completed is written if no errors occurred . A summary

of the error messages is provided in Table 15. The ERROR.TEX file is stored in the STH directory.

PROCEDURE USED TO DEVELOP SHIP RESPONSE TIME HISTORIES

The ACTH program is used to develop response time histories in random seas at various locations on the ship. In order to run the ACTH program the user must perform a number of tasks which involve:

1. Selection of ship,
2. Reviewing SMP84 output/running SMP84 program,
3. Reviewing STH runs/running STH program,
4. Editing ACTH input/running ACTH program.

The input required to run each of the three programs, SMP84, STH, and ACTH is specific to a particular ship. Each program however uses a generic input file name, SMP.INP, STH.INP, and ACTH.INP, respectively. The user must maintain these input files using both generic names as well as ship specific names. In order to change a ship, the user should first save the generic input files for the current ship to files that are identified by the ship name. For example, using the MS-DOS copy command at the MS-DOS prompt,

```
C:\COPY C:\STH\STH.INP C:\STH\DD965A.STH,
```

where the extension STH would identify the file as the STH input for the DD965A ship. The extensions SMP and ATH should be used for the input files for the SMP84 and ACTH programs. Next the user should copy the input files for the new ship to the generic files, i.e.,

```
C:\COPY C:\STH\FFG8A.ATH C:\ACTH.INP,
```

where the new ship is the FFG8A.

SMP84 is a frequency domain program that predicts statistical ship responses in random seas at various locations on the ship. The SMP input consists of ship offsets as a function of station, and loading information such as nominal GM, displacement, roll radius of gyration. Other input information describes the appendage suite, point locations for ship responses, and sea conditions. The information required to run the SMP84 program can be found in References 1 and 2.

A file called the origin file, DD965A.ORG for the DD965A ship,

is output from SMP84 and stored in the SMPDATA subdirectory. This file contains the 6DOF (surge, sway, heave, sway, heave, roll, and yaw) transfer functions computed at the LCG of the ship in the waterplane as a function of ship speed, heading, wave frequency, and mean roll angle. This file is required by the STH program to develop 6DOF time histories for specified speeds, headings, and sea conditions.

An additional text file containing the statistical ship responses is output from SMP84 and stored in the SMPDATA subdirectory. This file is called DD965AN.OUT where N is a cycle number which represents the last SMP84 run made for the DD965A ship. This output file can provide assistance in selecting conditions for which STH runs can be made. Note that one of the reasons for running the STH program is to obtain phase correlation between responses which is not provided in the SMP84 statistical tables. The statistical tables do identify the speeds, headings, and the modal wave periods where the maximum values occur for a large number of responses. Examples of the statistical response tables for roll as well as the vertical velocity at the helicopter deck bullseye are shown in Tables 16 and 17, respectively.

Once the STH run conditions have been selected from the SMP84 output and the SMP84 Origin file has been saved, the next task is to edit the STH input file. The user can review the STHLOG.TEX file to determine which STH runs have already been made. Note that the STHLOG.TEX file is located in the DD965A subdirectory of the STHDATA directory. The STH runs take a long time to execute, approximately 43 minutes per run on a 20-Mhz COMPAQ 386 personal computer, and should be run overnight or over a weekend.

The STH time histories form the data base from which response time histories are developed in the ACTH program. Once the STH time histories have been run, the last task is to edit the ACTH input file to select the point locations on the ship and the desired responses. The ACTH program executes very quickly, approximately 1 to 2 minutes for 16 channels, and can easily be run many times using different ACTH run numbers for different sets of channels or point locations.

TIME HISTORY EXAMPLE

SELECTION OF SHIP AND SEAWAY PARAMETERS

The DD965 destroyer is the example ship used to demonstrate the procedure required to develop response time histories. Four locations were selected as shown in Fig. 7. These locations are identified as:

1. Sonar dome,
2. Starboard side of the bridge,
3. Helicopter deck bullseye,
4. Port side of the stern.

The following nine responses were selected for running in the SMP84 and ACTH programs:

1. Wave height,
2. Roll angle,
3. Pitch angle,
4. Heave,
5. Relative motion at the sonar dome,
6. Earth system vertical acceleration on the starboard side of the bridge,
7. Earth system vertical velocity at the helicopter deck bullseye,
8. Earth system lateral acceleration at the helicopter deck bullseye,
9. Ship system lateral force at the helicopter deck bullseye.

The SMP84 program was run using a significant wave height of 12 feet and a roll statistic of 2. The origin transfer function file was saved as DD965A.ORG and the statistical response results were saved in the DD965A6.OUT output file. The input used for running SMP84 is shown in Table 18. A plot of the hull lines is shown in Fig. 8 and the ship hydrostatics are shown in Table 19. SMP84 optionally outputs the 6DOF Response Amplitude Operator (RAO) magnitudes and phases as a function of encountered wave frequency, ship speed, and relative wave heading. Note that the RAO magnitude is the square of the transfer function magnitude. An example of the RAO magnitudes

and phases for the 6DOF responses is shown in Table 20 for a ship speed of 20 knots and a relative wave heading of 45 degrees (bow waves).

Three representative STH runs were made using ship/sea conditions selected from the SMP84 statistical response tables. Shortcrested seas were used for all three runs. The significant wave height used was 12 feet. The modal wave period used was 9 seconds which is the most probable wave period for this significant wave height. The ship conditions selected were:

1. Beam seas (90 degrees), zero knots was used for STH run 1 to illustrate the wave time history,
2. Bow seas (45 degrees), 20 knots was used for STH run 2 to illustrate large pitch and vertical mode response time histories, and
3. Quartering seas (135 degrees), 20 knots was used for STH run 3 to illustrate large roll and lateral mode response time histories.

The STH input file is shown in Table 4. Note that two wave point locations, for the sonar dome and the port side of the stern, were used in the input in order to compute relative motion time histories at these points in the ACTH program. Each STH run took 43 minutes to execute for a total of 129 minutes. Each STH data file, SRN.DAT, used 133,900 bytes of storage.

Finally, three ACTH runs were made using the three STH runs as input. Response time histories were generated for the 9 responses previously identified. The ACTH input is shown in Table 9. Each ACTH run took 22 seconds for a total of 66 seconds using the binary data format option. The data storage for ARM.DAT was 133,900 bytes. If the ASCII data format is selected, the ACTH run time increases to 60 seconds per run and the ARM.ASC storage increases to 345,700 bytes.

ANALYSIS

Beam Sea Wave Time History

A 20-minute wave time history was computed at 3 samples per

second in STH run 1 for a ship speed of zero knots in shortcrested beam seas with a significant wave height of 12 feet and a modal wave period of 9 seconds. The first 300 seconds of this wave time history is shown in Fig. 9a. As shown in Fig. 9b, a power spectrum of the wave channel as well as a bimodal distribution of wave amplitudes (by single amplitude and period) was computed for the entire 20-minute duration of the run. There were a total of 158 cycles, where the period of each cycle is defined by three consecutive zero-crossings.

A comparison between the power spectrum computed from the wave time history and the Bretschneider wave spectral model is shown in Fig. 10a. The instantaneous wave elevations are compared with a Gaussian distribution in Fig. 10b. Finally, a comparison of the wave single amplitude distribution is compared with a Rayleigh distribution in Fig. 10c.

These comparisons show that the wave time history developed by the STH program does represent a random sea whose instantaneous wave elevations have a Gaussian distribution and whose single amplitudes have a Rayleigh distribution. Note that the Bretschneider wave spectrum, and the Gaussian and Rayleigh distributions represent averages from a large collection of time histories. The results obtained from any one time history for a specific set of random numbers (see Eq. 10) can be larger or smaller than these curves. However, the results should have the same general trends as the theoretical curves.

Since the linear superposition principle was used to obtain the ship response time histories to the random seas, it follows that the response elevations will also have a Gaussian distribution and the response single amplitudes will have a Rayleigh distribution. The single amplitudes for roll will have a modified Rayleigh distribution because of the increase in roll damping with increasing significant wave height.

Ship Response Time Histories in Bow & Stern Quartering Seas

Nine response time histories, including the encountered wave time history, were generated by the ACTH program at 3 samples per

second for 20 minutes in a shortcrested sea with a significant wave height of 12 feet and a modal wave period of 9 seconds. ACTH run 2 represents a bow sea (45 degree) ship heading and ACTH run 3 represents a stern quartering sea (135 degrees). Both runs are for a ship speed of 20 knots. The minimum analysis (standard deviation and peak values) of the nine responses for both ACTH runs is shown in Table 21.

A comparison of these responses for bow and stern quartering seas is provided in Figure 11. Time histories are shown for the encountered wave, roll angle, pitch angle, heave displacement, relative motion at the sonar dome, vertical acceleration at the starboard side of the bridge, and vertical velocity, lateral acceleration (earth-reference), and lateral force (ship-reference) for the center of the helicopter deck bullseye.

A representative 200 second section from each the 20 minute runs is compared in this figure. Note first that the encountered wave frequencies in bow seas are higher than for stern quartering seas at the ship speed of 20 knots. In fact there is not enough wave energy near the natural roll frequency (0.4 rps) in bow seas at this speed to excite the ship in roll. In general, the ship responses related to the vertical mode, i.e., pitch, heave, relative motion, and vertical velocity and acceleration are larger in bow seas than in stern quartering seas. Likewise, the ship responses related to the lateral mode, i.e., roll, lateral acceleration, and ship lateral force are larger in stern quartering seas where the encountered wave frequencies are smaller (longer periods) compared to bow seas. Vertical responses at point locations on the ship which are off centerline contain a roll component, and can thus show a resonance due to roll in stern quartering seas. Finally, note that the lateral force in the ship system is larger than the lateral acceleration in the earth system due to the component of gravity times the sine of the roll angle, which is much larger in stern quartering seas than in bow seas.

CONCLUDING REMARKS

The methods/programs described in this report provide a rational approach to the generation of simulated ship motions in random seas. These ship motion time histories in turn can be used to develop realistic ship motion specifications to which any ship subsystem can be designed. The intention in developing this tool is to allow a potential user to concentrate on developing the model of his subsystem and not on the generation/accuracy of the ship motion data base which will be used to drive the subsystem.

No software remains static. Future enhancements or expansion of these programs will depend not only on theoretical and technological improvements, but will rely heavily on the requirements of the users. It is, therefore, important that feedback be provided the authors so that later versions of the programs presented will meet the needs of the U.S. Navy.

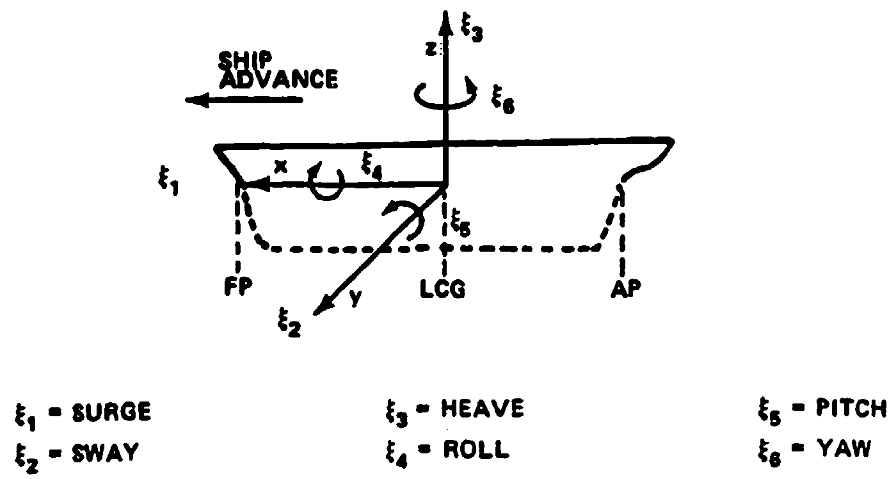


Fig. 1. Sign convention for translatory and angular displacements.

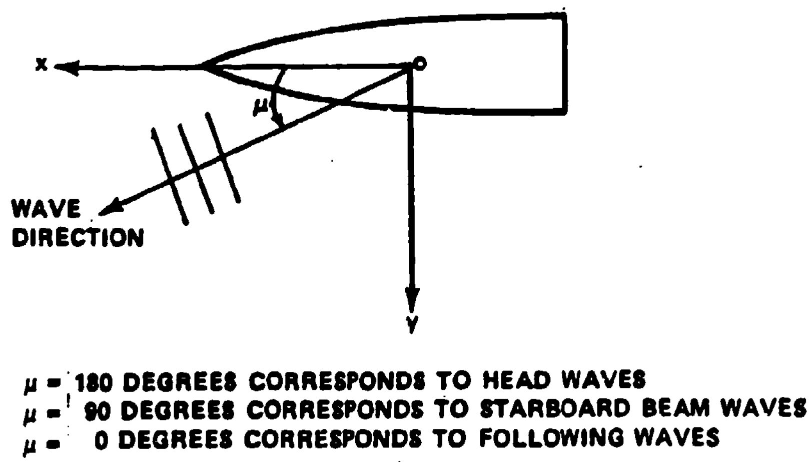


Fig. 2. Definition of computational heading, μ.

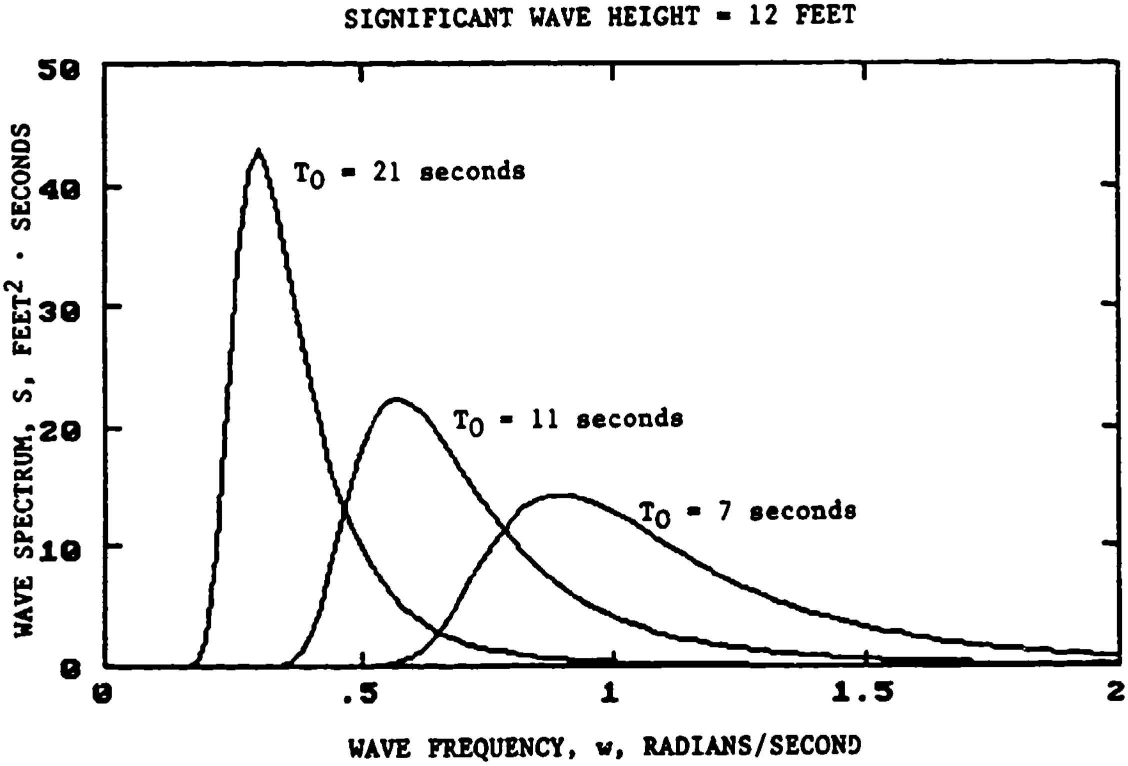
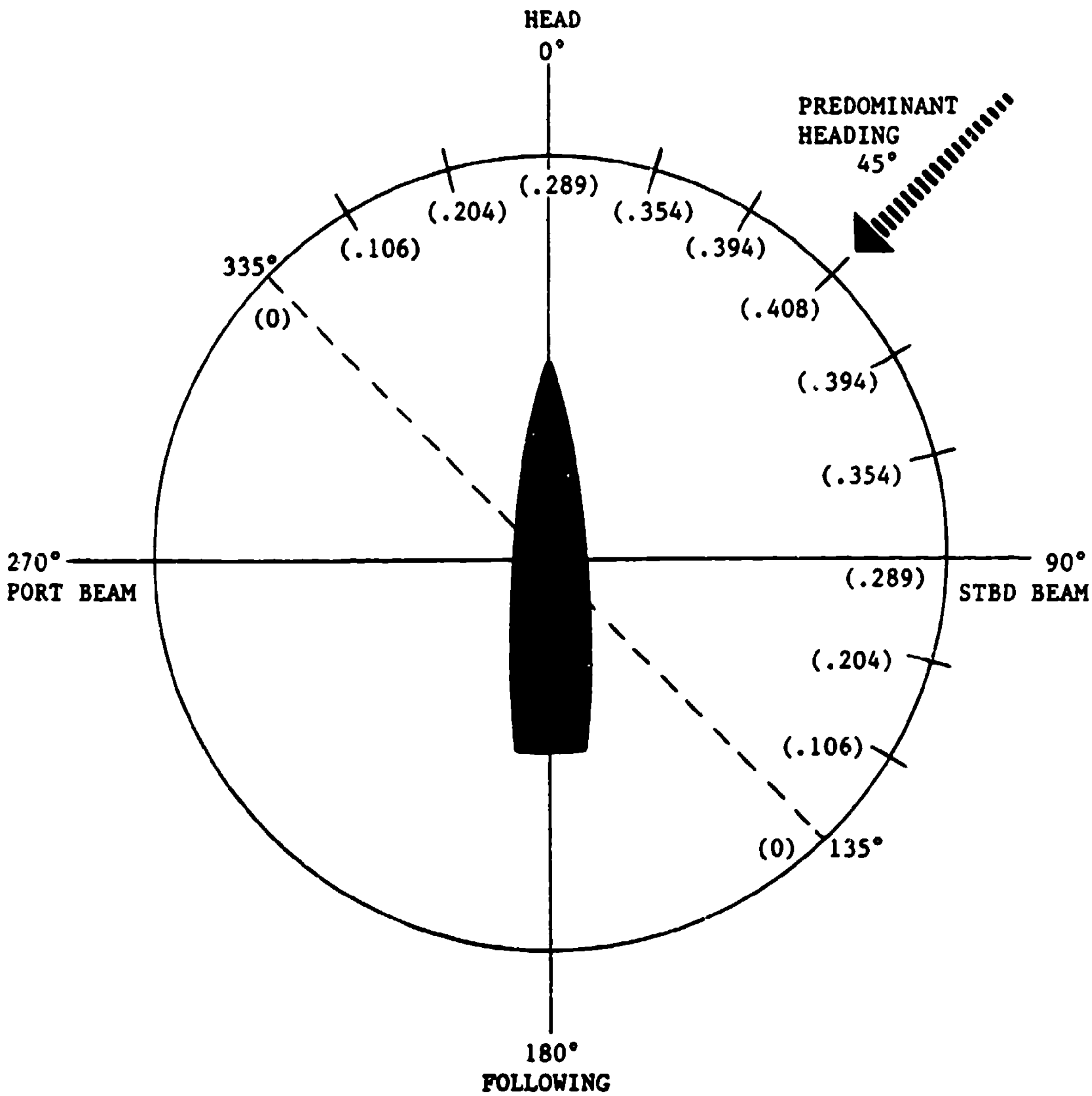


Fig. 3. Bretschneider wave spectra for 7, 11, and 21-second modal periods.



NOTE: NUMBERS IN PARANTHESES ARE SHORTCRESTING WEIGHTING CONSTANTS.

Fig. 4. Example of the shortcresting method for an output predominant heading of 45 degrees (bow seas).

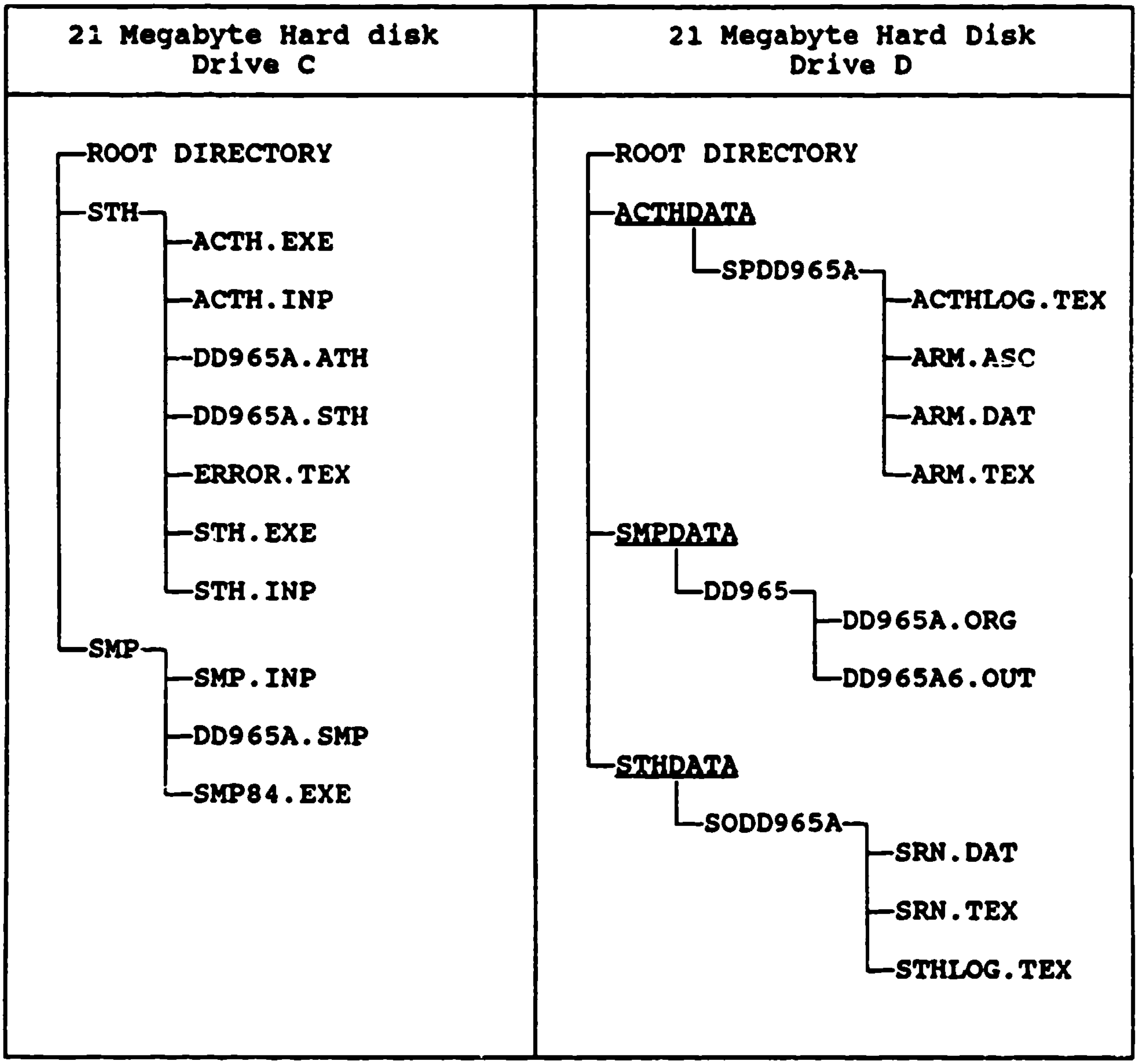


Fig. 5. Organization chart of STH, ACTH, and SMP84 directories and files.

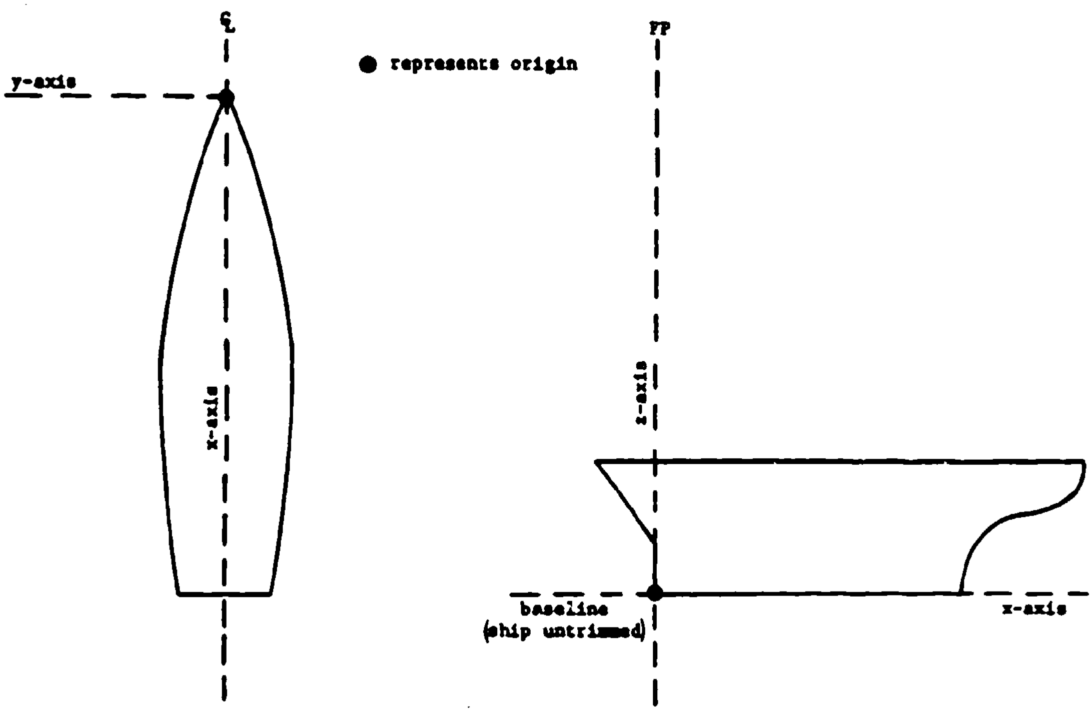
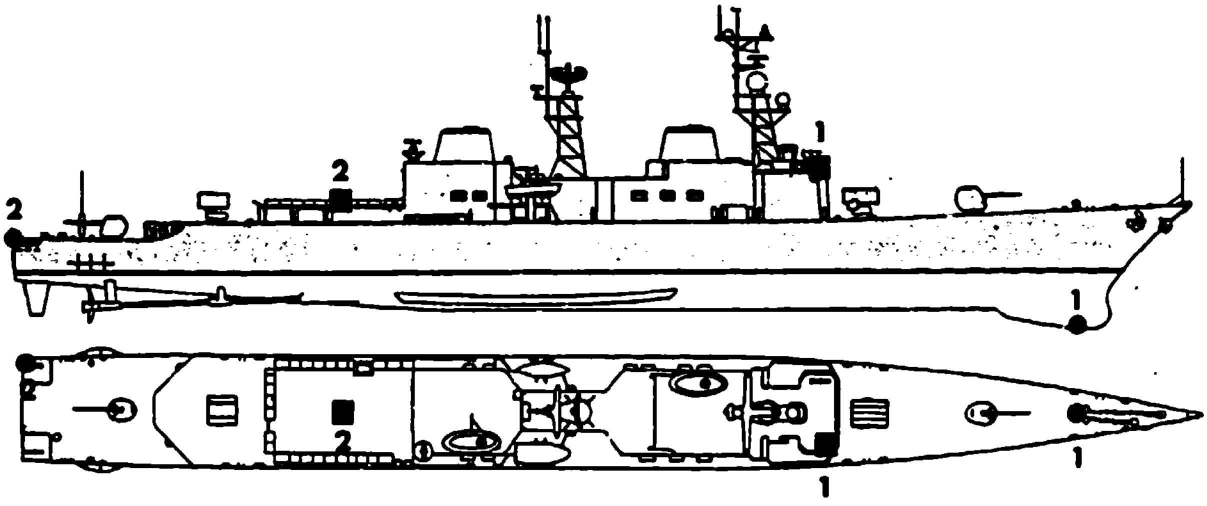


Fig. 6. Input reference system (SMP84).



WAVE POINTS ●	XFP (STATION #)	YCL (FT)	ZBL (FT)
1. SONAR DOME	0.8	0.0	-9.5
2. STERN, PORT SIDE	19.8	20.8	33.0

MOTION POINTS ■	XFP (STATION #)	YCL (FT)	ZBL (FT)
1. BRIDGE, STBD SIDE	5.5	-15.0	62.0
2. HELO DECK BULLSEYE	14.4	0.0	51.0

Fig. 7. Point locations on DD-965 for point time history example.

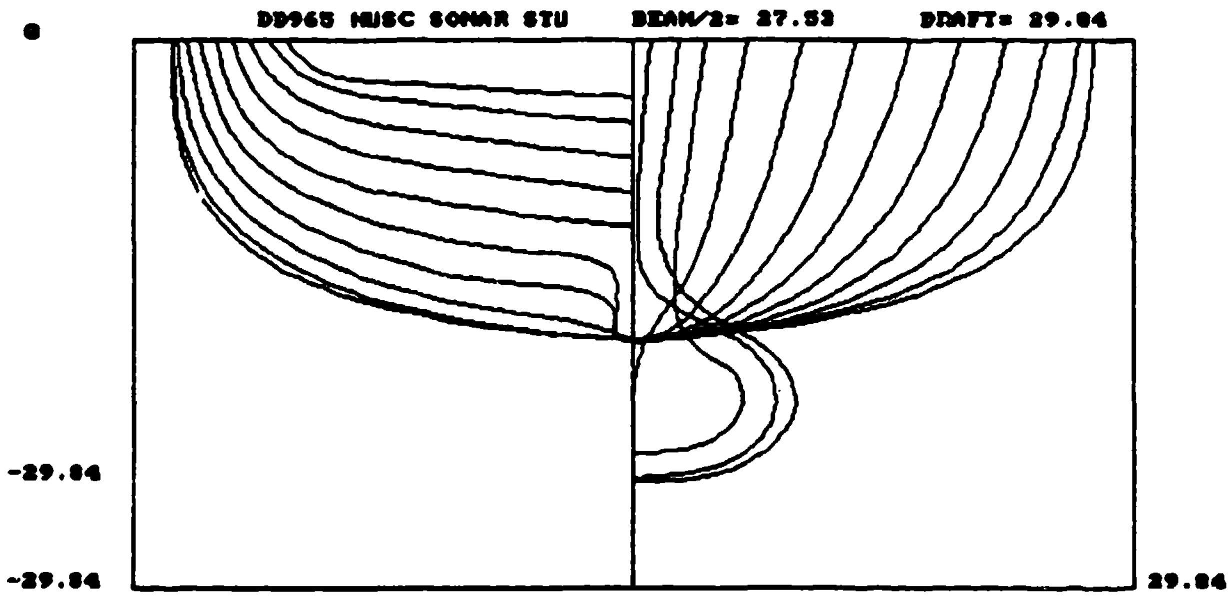


Fig. 8. Computer-generated hull lines for the DD-965.

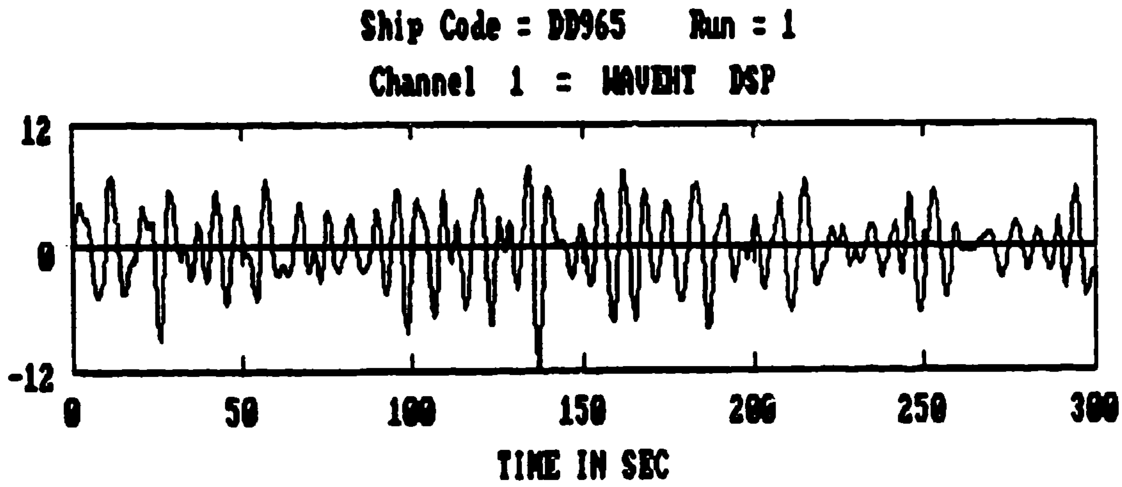


Fig. 9a. Time history of wave height displacement.

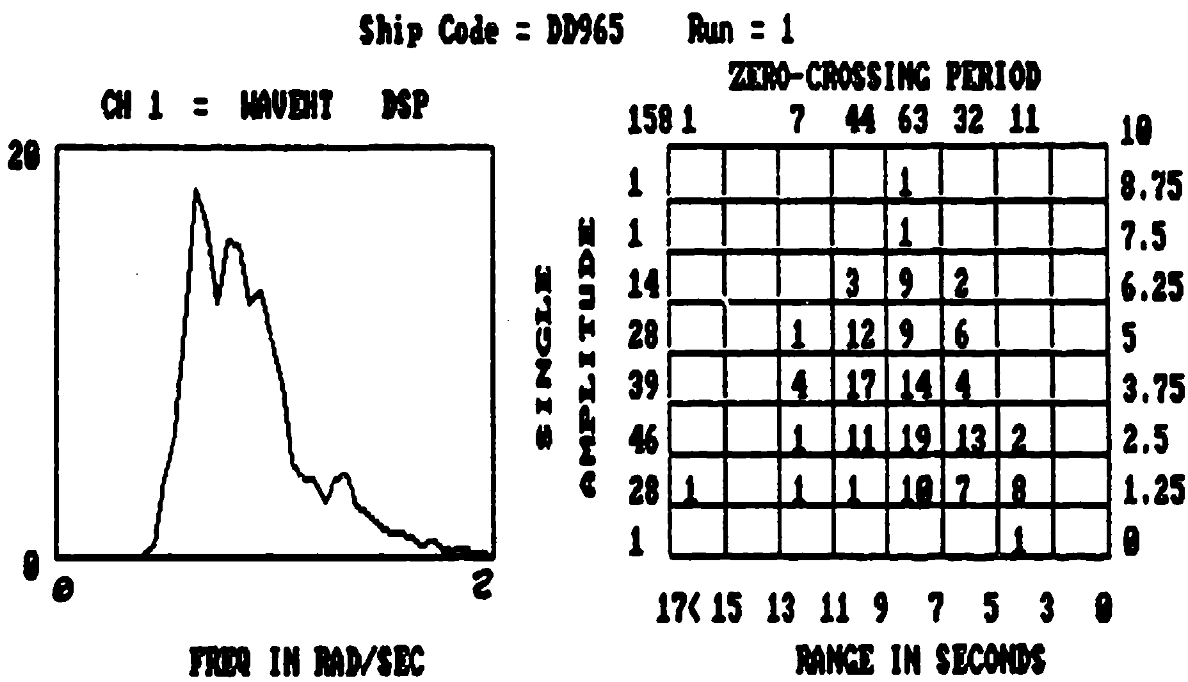


Fig. 9b. Spectrum and amplitude vs. period distribution.

Fig. 9. Example of wave behavior in shortcrested beam seas, significant wave height of 12 feet and modal wave period of 9 seconds.

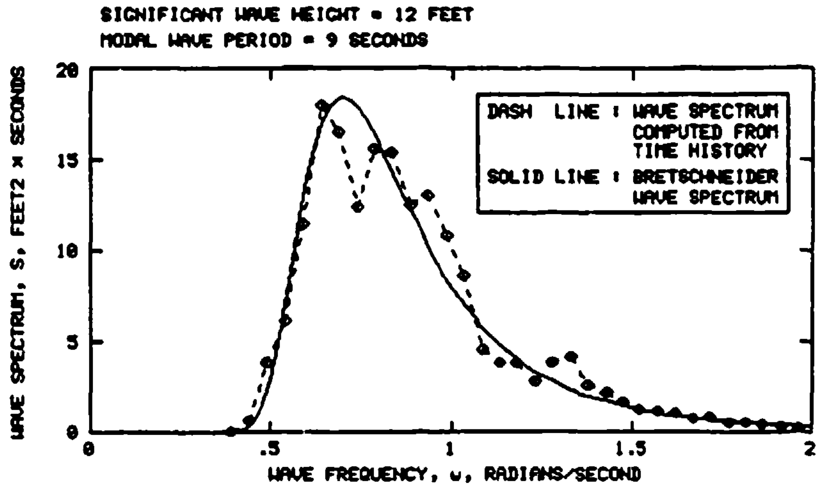


Fig. 10a. Computed wave spectrum vs. Bretschneider wave spectrum.

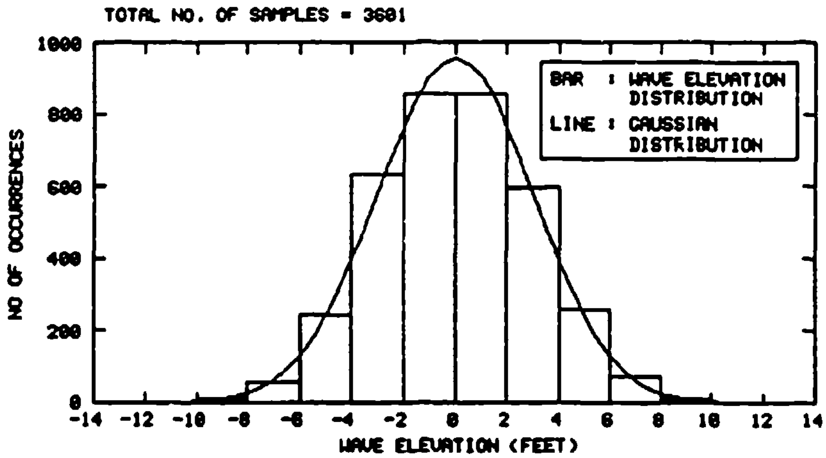


Fig. 10b. Wave elevation distribution vs. Gaussian distribution.

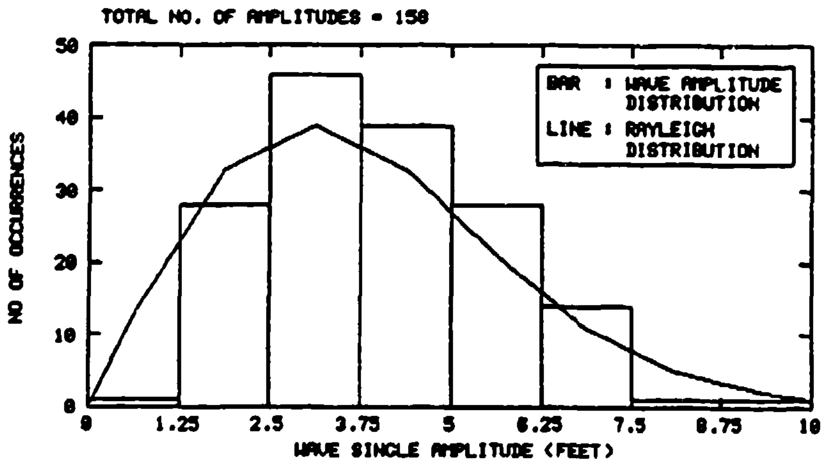


Fig. 10c. Wave single amplitude distribution vs. Rayleigh distribution.

Fig. 10. Analysis comparison of beam seas wave time history with theoretical predictions.

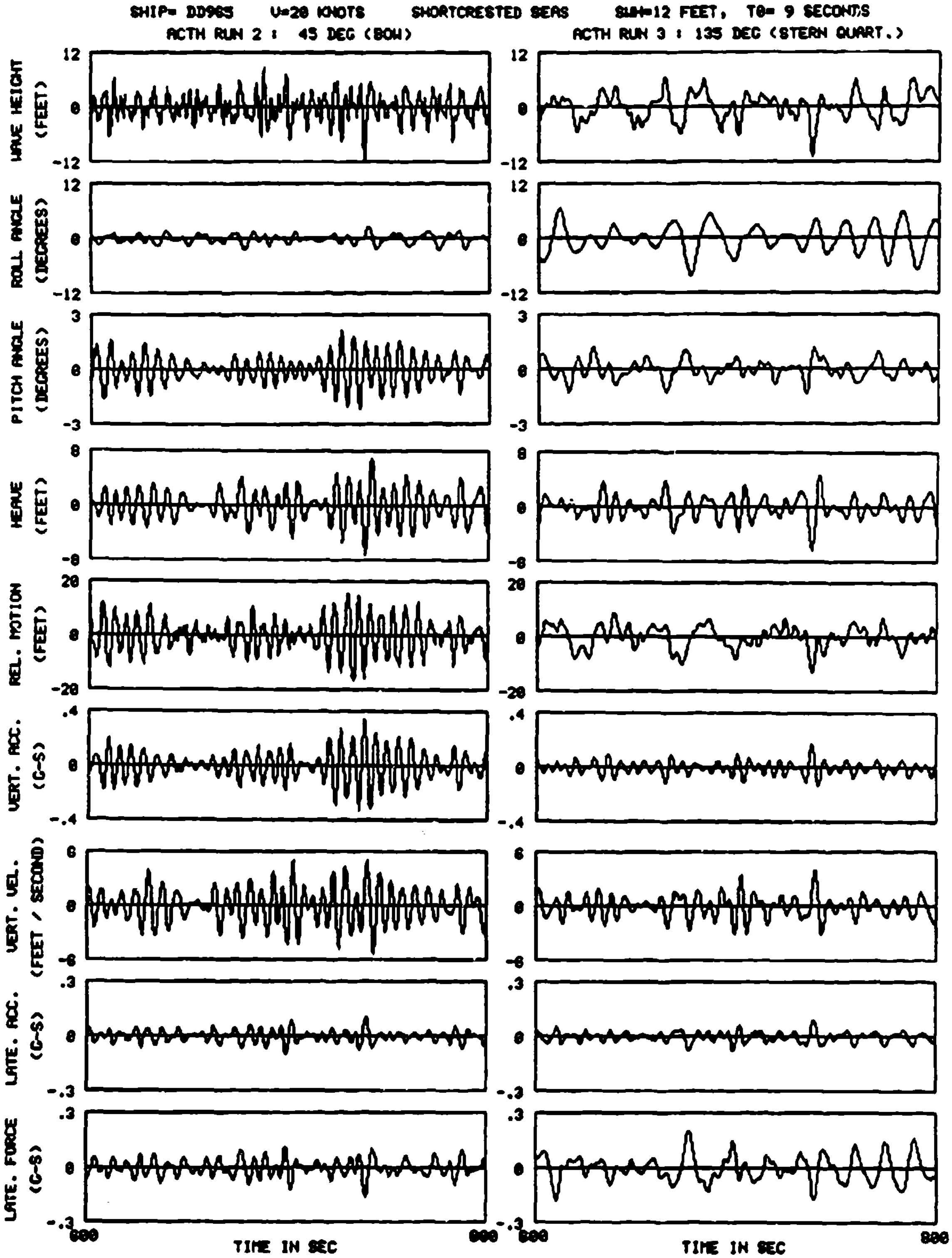


Fig. 11. Comparison of computed time histories for the DD-965 at 20 knots in shortcrested bow and stern quartering seas.

Table 1. Constants for single amplitude Rayleigh statistics.

SINGLE AMPLITUDE STATISTICS	
Root mean square amplitude, RMS	$1.00\ \sigma$
Average amplitude	$1.25\ \sigma$
Average of highest 1/3 amplitudes, significant	$2.00\ \sigma$
Highest expected amplitude in 10 successive amplitudes	$2.15\ \sigma$
Average of highest 1/10 amplitudes	$2.55\ \sigma$
Highest expected amplitude in 30 successive amplitudes	$2.61\ \sigma$
Highest expected amplitude in 50 successive amplitudes	$2.80\ \sigma$
Highest expected amplitude in 100 successive amplitudes	$3.03\ \sigma$
Highest expected amplitude in 200 successive amplitudes	$3.25\ \sigma$
Highest expected amplitude in 1000 successive amplitudes	$3.72\ \sigma$

DEFINITIONS

σ^2 = Statistical variance of time history.

N = Number of successive amplitudes.

CONSTANT = $\sqrt{2}\ (\ln N)^{1/2}$, where CONSTANT relates σ to the highest expected amplitude in N successive amplitudes.

NOTES:

1. The highest expected amplitude in N amplitudes is the most probable extreme value in N amplitudes. This value may be exceeded 63 percent of the time.

2. To obtain wave height or double amplitude statistics from RMS values, multiply single amplitude constants by 2.0.

Table 2. Summary of files used by the STH program.

FILE	NAME	TYPE	DESCRIPTION
1.	STH.INP	ASCII	Input for the STH program describing wave point locations and STH run conditions
2.	DD965A.ORG	Binary	SMP84 6DOF (Origin) transfer functions
3.	SRN.TEX	ASCII	Summary of conditions and statistical results for wave and 6DOF channels for STH run N
4.	SRN.DAT	Binary	Wave and 6DOF time histories for STH run N
5.	STHLOG.TEX	ASCII	Summary of STH runs and conditions

Table 3. STH data set summary.

STH Data Set	Definition
1	SMP DATA PATH
2	STH DATA PATH
3	SHIP TYPE
4	SHIP NAME
5	HULL VARIANT
6	CYCLE NO
7	UNITS
8	TITLE
9	WAVE POINT INPUT
10	RUN INPUT

Table 5. (Continued)

FIRST 20 SECONDS OF WAVE HEIGHT AND 6DOF TIME HISTORIES

TIME SEC	WAVEHT FEET	SURGE FEET	SWAY FEET	HEAVE FEET	ROLL DEG	PITCH DEG	YAW DEG
0.00	-2.800	1.185	-3.233	-2.212	4.369	0.014	0.287
0.33	-2.082	0.967	-3.423	-1.386	3.328	0.005	0.162
0.67	-1.307	0.755	-3.461	-0.428	2.143	0.037	0.025
1.00	-0.583	0.567	-3.345	0.585	0.837	0.101	-0.113
1.33	0.034	0.380	-3.073	1.559	-0.521	0.183	-0.242
1.67	0.638	0.220	-2.656	2.415	-1.872	0.260	-0.355
2.00	1.245	0.062	-2.123	3.080	-3.152	0.319	-0.446
2.33	1.706	-0.084	-1.500	3.515	-4.334	0.345	-0.517
2.67	1.763	-0.226	-0.829	3.694	-5.372	0.332	-0.573
3.00	1.333	-0.366	-0.143	3.618	-6.259	0.281	-0.618
3.33	0.580	-0.504	0.515	3.319	-6.983	0.198	-0.656
3.67	-0.229	-0.637	1.120	2.839	-7.556	0.094	-0.690
4.00	-0.912	-0.770	1.642	2.233	-7.954	-0.018	-0.718
4.33	-1.410	-0.907	2.068	1.562	-8.179	-0.126	-0.736
4.67	-1.724	-1.045	2.394	0.882	-8.220	-0.225	-0.738
5.00	-1.904	-1.194	2.628	0.241	-8.074	-0.312	-0.715
5.33	-2.024	-1.355	2.782	-0.314	-7.724	-0.386	-0.662
5.67	-2.123	-1.539	2.877	-0.756	-7.178	-0.451	-0.577
6.00	-2.124	-1.737	2.931	-1.071	-6.441	-0.507	-0.457
6.33	-1.900	-1.965	2.961	-1.263	-5.533	-0.551	-0.309
6.67	-1.478	-2.217	2.978	-1.351	-4.474	-0.581	-0.137
7.00	-1.143	-2.493	2.978	-1.367	-3.304	-0.590	0.049
7.33	-1.197	-2.792	2.954	-1.353	-2.060	-0.572	0.237
7.67	-1.682	-3.103	2.889	-1.350	-0.778	-0.519	0.419
8.00	-2.370	-3.420	2.768	-1.398	0.503	-0.427	0.588
8.33	-3.013	-3.737	2.576	-1.517	1.743	-0.290	0.737
8.67	-3.605	-4.047	2.302	-1.720	2.920	-0.111	0.861
9.00	-4.263	-4.333	1.950	-1.992	4.003	0.104	0.954
9.33	-5.002	-4.599	1.521	-2.310	4.959	0.344	1.014
9.67	-5.621	-4.826	1.041	-2.631	5.778	0.593	1.039
10.00	-5.930	-5.015	0.531	-2.916	6.441	0.838	1.031
10.33	-5.888	-5.156	0.020	-3.112	6.940	1.063	0.994
10.67	-5.615	-5.245	-0.463	-3.181	7.254	1.254	0.930
11.00	-5.213	-5.281	-0.899	-3.093	7.379	1.399	0.840
11.33	-4.684	-5.257	-1.265	-2.841	7.319	1.486	0.731
11.67	-3.974	-5.175	-1.555	-2.427	7.065	1.515	0.601
12.00	-3.052	-5.036	-1.757	-1.876	6.631	1.487	0.458
12.33	-1.900	-4.841	-1.874	-1.218	6.033	1.409	0.306
12.67	-0.543	-4.593	-1.906	-0.505	5.290	1.290	0.150
13.00	0.947	-4.302	-1.862	0.219	4.425	1.140	-0.005
13.33	2.434	-3.966	-1.753	0.906	3.463	0.967	-0.156
13.67	3.758	-3.599	-1.594	1.514	2.432	0.784	-0.296
14.00	4.809	-3.203	-1.400	2.008	1.359	0.597	-0.420
14.33	5.516	-2.783	-1.188	2.370	0.267	0.414	-0.524
14.67	5.807	-2.352	-0.971	2.595	-0.803	0.241	-0.604
15.00	5.691	-1.914	-0.757	2.696	-1.849	0.082	-0.659
15.33	5.288	-1.476	-0.550	2.690	-2.829	-0.060	-0.689
15.67	4.802	-1.033	-0.352	2.606	-3.724	-0.182	-0.696
16.00	4.367	-0.601	-0.159	2.473	-4.513	-0.280	-0.683
16.33	3.957	-0.170	0.038	2.325	-5.202	-0.350	-0.658
16.67	3.457	0.250	0.247	2.185	-5.772	-0.388	-0.624
17.00	2.832	0.669	0.474	2.066	-6.212	-0.396	-0.580
17.33	2.168	1.078	0.725	1.980	-6.551	-0.376	-0.534
17.67	1.555	1.481	1.000	1.920	-6.765	-0.336	-0.485
18.00	1.040	1.875	1.289	1.865	-6.849	-0.286	-0.434
18.33	0.678	2.255	1.577	1.797	-6.792	-0.238	-0.381
18.67	0.550	2.624	1.851	1.684	-6.579	-0.205	-0.329
19.00	0.655	2.969	2.086	1.507	-6.200	-0.196	-0.277
19.33	0.833	3.301	2.266	1.249	-5.656	-0.219	-0.229
19.67	0.844	3.600	2.370	0.916	-4.954	-0.273	-0.184
20.00	0.602	3.873	2.389	0.521	-4.123	-0.357	-0.144

Table 5. (Continued)

STATISTICAL RESULTS

CHAN	NAME	UNIT	TIME DOMAIN MEAN	STDDEV	MAX	MIN	FREQ. DOMAIN STDDEV
1	WAVEHT	FEET	-0.005	2.800	8.089	-10.766	2.980
2	SURGE	FEET	0.018	2.662	7.005	-7.783	2.941
3	SWAY	FEET	0.020	1.496	4.762	-4.633	1.588
4	HEAVE	FEET	0.002	1.557	5.098	-6.218	1.536
5	ROLL	DEG	-0.009	3.338	10.148	-8.743	4.083
6	PITCH	DEG	0.002	0.472	1.515	-1.338	0.511
7	YAW	DEG	-0.001	0.575	1.714	-1.472	0.653
8	WVHTP1	FEET	0.004	2.779	8.555	-8.440	2.980
9	WVHTP2	FEET	0.030	2.550	7.271	-8.811	2.980

ELAPSED TIME

0 Hours 43 Minutes 16 Seconds

Table 6. Example of STHLOG.TEX file.

STH LOG RUN SUMMARY

TRIAL: DD965 NUSC SONAR STUDY (ARMORED, TRIMMED

STH DATA PATH : C:\STHDATA\SODD965A

TYPE CODE : BI - BINARY

RUN	TYPE	TIME	DATE-TIME-GROUP	COMMENTS				
1	BI	20.0 MIN	011017L SEP89	SC	V= 0	HD= 90	SWH=12.0	TO= 9
2	BI	20.0 MIN	011054L SEP89	SC	V=20	HD= 45	SWH=12.0	TO= 9
3	BI	20.0 MIN	011137L SEP89	SC	V=20	HD=135	SWH=12.0	TO= 9

Table 7. Summary of files used by the ACTH program.

FILE	NAME	TYPE	DESCRIPTION
1.	ACTH.INP	ASCII	Input for the ACTH program describing wave point locations, point locations, channel identification, and STH run numbers
2.	SRN.TEX	ASCII	Summary of conditions and statistical results fcr wave and 6DOF channels for STH run N
3.	SRN.DAT	Binary	Wave and 6DOF time histories for STH run N
4.	ARM.TEX	ASCII	Summary of point locations, channel identification, run conditions, and channel statistical results for ACTH run M
5.	ARM.DAT	Binary	Time histories for up to 16 ACTH channels for ACTH run M (optional data format used when variable ASCII=1)
6.	ARM.ASC	ASCII	Time histories for up to 16 ACTH channels for ACTH run M (optional data format used when variable ASCII=2)
7.	ACTHLOG.TEX	ASCII	Summary of ACTH runs and conditions
8.	ERROR.TEX	ASCII	Summary of errors detected when ACTH program was executed

Table 8. ACTH data set summary.

ACTH Data Set	Definition
1	STH DATA PATH
2	ACTH DATA PATH
3	SHIP NAME
4	OUTPUT DATA FORMAT
5	WAVE POINT INPUT
6	POINT INPUT
7	CHANNEL INPUT
8	START ACTH RUN
9	NO OF ACTH RUNS
10	STH RUN INPUT

Table 9. Example of ACTH.INP file.

```
D:\STHDATA\SODD965A
D:\ACTHDATA\SPDD965A
DD965

OUTPUT= 1

NO OF WAVE POINTS= 2

                    List of Wave Points
  NO      XLOC      YLOC      ZLOC        NAME
   1       0.8       0.0      -9.5    SONAR DOME
   2      19.8      20.8      33.0    STERN PORT SIDE

NO OF POINTS= 2

                    List of Points
  NO      XLOC      YLOC      ZLOC        NAME
   1       5.5     -15.0      62.0    BRIDGE STBD SIDE
   2      14.4       0.0      51.0    HELO DECK BULLSEYE

NO OF CHANNELS= 9

  List of Channels with Associated Points
  NO    RESP    TYPE    SYSTEM    POINT
   1      7       1        1        0
   2      4       1        1        0
   3      5       1        1        0
   4      3       1        1        0
   5      4       1        1        1
   6      3       3        1        1
   7      3       2        1        2
   8      2       3        1        2
   9      2       3        2        2

START ACTH RUN= 1
NO OF ACTH RUNS= 3

STH RUNS
 1
 2
 3

** Description of BATCH input for ACCESS Time History Program **

STH TIME HISTORY PATH    -   up to 80 characters
ACTH TIME HISTORY PATH   -   up to 80 characters
SHIP NAME    -   up to  5 characters
OUTPUT  -  Data format  1 = binary,  2 = ASCII
NO OF WAVE POINTS
LIST OF WAVE POINTS  -  (X, Y, Z LOCATIONS AND WAVE POINT NAMES)
NO OF POINTS LIST OF POINTS  -  (X, Y, Z LOCATIONS AND POINT NAMES)
NO OF CHANNELS
CHANNEL LIST INCLUDING ASSOCIATED POINT LOCATIONS
START RUN NO FOR ACTH RUNS
NO OF ACTH RUNS
STH RUN NO
```

Table 10. Method used to select ACTH channels.

Select Point No

Point no = 0 - Location (Origin) is at LCG in the waterplane

SYSTEM = EARTH

Select Response No
1 - Surge
2 - Sway
3 - Heave
4 - Roll
5 - Pitch
6 - Yaw
7 - Wave Height at LCG

Select Type
1 - Displacement/Angle
2 - Velocity
3 - Acceleration

Point no > 0 - Any location on the ship

Select system

SYSTEM = EARTH

Select Response No
1 - Longitudinal reponse at a point
2 - Lateral " "
3 - Vertical " "
4 - Relative motion at a wave point
7 - Wave height at a wave point

Select Type
1 - Displacement
2 - Velocity
3 - Acceleration

SYSTEM = SHIP

Select Response No
1 - Longitudinal force at a point
2 - Lateral " "
3 - Vertical " "

Select Type
3 - Acceleration (force per unit mass)

Table 11. ACTH menu screen.

```
Access Time History Program (ACTH)


     Total number of runs =  3

     Start run number = 1


     Working on run number 3
```

Table 12. Example of AR3.TEX file.

```
RUN DATE-TIME-GROUP = 032106L SEP89

032106L SEP89, 0, 0,  135, 0, 0, 12.0,   9

--------------------------------------------------------------

TRIAL: DD965 NUSC SONAR STUDY (ARMORED, TRIMMED

UIC CODE:  DD965

RUN:   3

COMMENTS:  SC  V= 20  HD= 135  SWH= 12.0  TO=  9

CORRESPONDING STH RUN:    3

SAMPLE RATE :  3.0
START TIME:      0.0
STOP  TIME:   1200.0
RUN   TIME:   1200.0

SHIP TYPE: DESTROYR
SHIP:  DD965
HULL VARIANT:  A
SMP CYCLE NO:  6

UNITS:  FEET
GRAVITY:      32.1700
SHIP LENGTH:    529
LONGITUDINAL CENTER OF GRAVITY (REF FROM FP):      272.30
DISTANCE FROM BASELINE TO WATERLINE:        20.30

SHIP SPEED: 20.00 KNOTS

PREDOMINANT HEADING :  135. DEG

    SMP OUTPUT HEADING REF. :
   -------------------------
        0 deg=head seas,
       90 deg=stbd beam seas,
      180 deg=following seas

SEA TYPE :  SHORTCRESTED SEAS
SIGNIF. WAVE HEIGHT :  12.00 FEET
MODAL WAVE PERIOD   :   9.00 SEC

STATISTIC USED FOR ROLL ITERATION :   2.00 * RMS

                                  STH PROGRAM
                              STATISTICAL RESULTS

                            TIME DOMAIN    FREQ. DOMAIN
CHAN    NAME      UNIT        STDDEV         STDDEV

  1    WAVEHT     FEET        2.800          2.980
  2    SURGE      FEET        2.662          2.961
  3    SWAY       FEET        1.496          1.588
  4    HEAVE      FEET        1.557          1.536
  5    ROLL       DEG         3.338          4.083
  6    PITCH      DEG         0.472          0.511
  7    YAW        DEG         0.575          0.653
  8    WVHTP1     FEET        2.779          2.980
  9    WVHTP2     FEET        2.550          2.980

NO OF WAVE POINTS:   2

                              List of Wave Points

            NO   XLOC    YLOC    ZLOC       NAME
            ------------------------------------------------
             1    0.8     0.0    -9.5    SONAR DOME
             2   19.8    20.8    33.0    STERN PORT SIDE
```

Table 12. (Continued)

NO OF POINTS: 2

List of Points

NO	XLOC	YLOC	ZLOC	NAME
1	5.5	-15.0	62.0	BRIDGE STBD SIDE
2	14.4	0.0	51.0	HELO DECK BULLSEYE

NO OF CHANNELS: 9

List of Channels with Associated Points

	CHANNEL				POINT				
NO	NAME	TYPE	UNIT	SYSTEM	NO	XLOC	YLOC	ZLOC	NAME
1	WAVEHT	DSP	FEET	EARTH	0	10.29	0.0	20.3	Origin (LCG, CL, WP)
2	ROLL	ANG	DEG	EARTH	0	10.29	0.0	20.3	Origin (LCG, CL, WP)
3	PITCH	ANG	DEG	EARTH	0	10.29	0.0	20.3	Origin (LCG, CL, WP)
4	HEAVE	DSP	FEET	EARTH	0	10.29	0.0	20.3	Origin (LCG, CL, WP)
5	RELMOT	DSP	FEET	EARTH	1	0.80	0.0	-9.5	SONAR DOME
6	VERT	ACC	G-S	EARTH	1	5.50	-15.0	62.0	BRIDGE STBD SIDE
7	VERT	VEL	FPS	EARTH	2	14.40	0.0	51.0	HELO DECK BULLSEYE
8	LATE	ACC	G-S	EARTH	2	14.40	0.0	51.0	HELO DECK BULLSEYE
9	SLATE	ACC	G-S	SHIP	2	14.40	0.0	51.0	HELO DECK BULLSEYE

M I N I M U M   A N A L Y S I S

CHAN	TITLE		UNITS	MEAN	STD. DEV.	MAX	MIN
1	WAVEHT	DSP	FEET	-4.738E-03	2.800E+00	8.089E+00	-1.077E+01
2	ROLL	ANG	DEG	-8.978E-03	3.338E+00	1.015E+01	-8.743E+00
3	PITCH	ANG	DEG	1.697E-03	4.720E-01	1.515E+00	-1.338E+00
4	HEAVE	DSP	FEET	1.868E-03	1.557E+00	5.098E+00	-6.218E+00
5	RELMOT	DSP	FEET	4.202E-02	3.562E+00	1.101E+01	-1.305E+01
6	VERT	ACC	G-S	6.821E-06	4.163E-02	3.269E-01	-1.402E-01
7	VERT	VEL	FPS	1.808E-03	1.084E+00	3.972E+00	-3.220E+00
8	LATE	ACC	G-S	1.817E-07	2.587E-02	1.686E-01	-7.665E-02
9	SLATE	ACC	G-S	-4.422E-05	7.559E-02	2.097E-01	-2.403E-01

CHANNEL NO./TITLE			Peak	Mean	STDDEV
1	WAVEHT	DSP	-1.077E+01	-4.738E-03	2.800E+00
2	ROLL	ANG	1.015E+01	-8.978E-03	3.338E+00
3	PITCH	ANG	1.515E+00	1.697E-03	4.720E-01
4	HEAVE	DSP	-6.218E+00	1.868E-03	1.557E+00
5	RELMOT	DSP	-1.305E+01	4.202E-02	3.562E+00
6	VERT	ACC	3.269E-01	6.821E-06	4.163E-02
7	VERT	VEL	3.972E+00	1.808E-03	1.084E+00
8	LATE	ACC	1.686E-01	1.817E-07	2.587E-02
9	SLATE	ACC	-2.403E-01	-4.422E-05	7.559E-02

Total number of data records this run = 3601

Table 13. Example of AR3.ASC file.

3601	9								
1	1	-2.800	4.369	0.014	-2.212	0.097	0.000	0.000	0.000
	2	-0.076							
2	1	-2.082	3.328	0.005	-1.386	0.271	0.327	2.536	0.169
	2	-0.240							
3	1	-1.307	2.143	0.037	-0.428	0.151	0.020	3.148	0.071
	2	-0.110							
4	1	-0.583	0.837	0.101	0.585	-0.221	-0.001	3.456	0.062
	2	-0.077							
5	1	0.034	-0.521	0.183	1.559	-0.750	-0.024	3.391	0.046
	2	-0.037							
6	1	0.638	-1.872	0.260	2.415	-1.200	-0.037	2.961	0.031
	2	0.000							
7	1	1.245	-3.152	0.319	3.080	-1.386	-0.053	2.242	0.010
	2	0.041							
8	1	1.706	-4.334	0.345	3.515	-1.289	-0.055	1.330	0.000
	2	0.069							
9	1	1.763	-5.372	0.332	3.694	-1.066	-0.060	0.322	-0.017
	2	0.101							
10	1	1.333	-6.259	0.281	3.618	-0.898	-0.059	-0.663	-0.025
	2	0.124							

Table 14. Example of ACTHLOG.TEX file.

ACTH LOG RUN SUMMARY

TRIAL: DD965 NUSC SONAR STUDY (ARMORED, TRIMMED

ACTH DATA PATH : D:\ACTHDATA\SPDD965A

TYPE CODE : BI - BINARY, AS - ASCII

RUN	TYPE	TIME	DATE-TIME-GROUP	COMMENTS				
1	BI	20.0 MIN	032105L SEP89	SC	V= 0	HD= 90	SWH=12.0	TO= 9
2	BI	20.0 MIN	032105L SEP89	SC	V=20	HD= 45	SWH=12.0	TO= 9
3	BI	20.0 MIN	032106L SEP89	SC	V=20	HD=135	SWH=12.0	TO= 9

Table 15. ACTH error message summary.

ERROR	MESSAGE
1	ERROR - ACTH program stopped. CHANNEL RESPONSE POINT I J K does not have a corresponding wave point number in ACTH.INP
2	STH run N does not exist
3	STH run N skipped because there are no wave points in the STH run
4	STH run X skipped because the STH wave points do not match the ACTH wave points
5	All STH runs were successfully completed

Table 16. Example of roll angle RSV table.

DD965 NUSC SONAR STUDY (ARMORED, TRIMMED BY BOW .22' OA) 5/13/85 TRA

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 12.00 FEET

ROLL ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	9	1.43/10	1.49/10	1.66/10	1.87/10	2.04/10	2.14/10	2.16/10	2.09/10	1.95/10	1.75/10	1.54/11	1.37/11	1.30/11
	11	3.03/15	3.12/15	3.34/15	3.61/15	3.85/15	4.01/15	4.05/15	3.98/15	3.79/15	3.54/15	3.26/15	3.03/15	2.95/15
	13	4.80/16	4.91/16	5.20/16	5.55/16	5.87/16	6.08/16	6.15/16	6.06/16	5.83/16	5.50/16	5.14/16	4.85/16	4.74/16
	15	5.58/16	5.71/16	6.03/16	6.44/16	6.80/16	7.04/16	7.12/16	7.03/16	6.77/16	6.39/16	5.98/16	5.66/16	5.53/16
	17	5.66/16	5.79/16	6.12/16	6.52/16	6.89/16	7.14/16	7.23/16	7.13/16	6.86/16	6.48/16	6.07/16	5.74/16	5.61/16
	19	5.38/16	5.51/16	5.82/16	6.21/16	6.56/16	6.80/16	6.88/16	6.79/16	6.54/16	6.18/16	5.78/16	5.46/16	5.34/16
	21	4.98/16	5.09/16	5.38/16	5.75/16	6.07/16	6.29/16	6.37/16	6.28/16	6.05/16	5.72/16	5.35/16	5.05/16	4.94/16
5	9	1.19/ 9	1.26/ 9	1.44/ 9	1.68/10	1.92/10	2.13/10	2.29/11	2.35/11	2.33/12	2.23/12	2.09/12	1.97/13	1.92/13
	11	1.95/12	2.04/12	2.29/12	2.66/14	3.09/15	3.51/15	3.87/15	4.09/15	4.17/15	4.11/15	3.98/15	3.85/15	3.80/15
	13	3.09/15	3.22/15	3.55/15	4.02/15	4.55/15	5.05/15	5.45/15	5.68/15	5.72/15	5.59/15	5.37/15	5.16/15	5.08/15
	15	3.91/15	4.05/15	4.40/15	4.89/15	5.40/15	5.86/16	6.19/16	6.34/16	6.29/16	6.08/16	5.78/16	5.52/16	5.42/16
	17	4.18/15	4.31/15	4.65/16	5.11/16	5.58/16	5.97/16	6.22/16	6.30/16	6.20/16	5.94/16	5.60/16	5.32/16	5.20/16
	19	4.08/16	4.20/16	4.52/16	4.94/16	5.36/16	5.69/16	5.89/16	5.92/16	5.78/16	5.51/16	5.17/16	4.88/16	4.77/16
	21	3.81/16	3.92/16	4.22/16	4.59/16	4.96/16	5.25/16	5.40/16	5.41/16	5.26/16	4.99/16	4.66/16	4.39/16	4.28/16
10	9	1.05/ 8	1.12/ 8	1.31/ 8	1.60/ 9	2.00/11	2.49/13	2.99/14	3.41/14	3.69/14	3.85/15	3.93/15	3.97/15	3.98/15
	11	1.52/10	1.61/10	1.86/11	2.31/14	2.97/15	3.74/15	4.50/15	5.09/15	5.46/15	5.64/15	5.70/15	5.70/15	5.70/15
	13	2.15/15	2.27/15	2.62/15	3.18/15	3.93/15	4.75/15	5.50/16	6.06/16	6.37/16	6.45/16	6.39/16	6.30/16	6.27/16
	15	2.76/15	2.90/15	3.27/15	3.84/16	4.52/16	5.23/16	5.85/16	6.28/16	6.47/16	6.44/16	6.28/16	6.11/16	6.04/16
	17	3.08/16	3.21/16	3.57/16	4.08/16	4.66/16	5.24/16	5.72/16	6.02/16	6.11/16	6.00/16	5.78/16	5.58/16	5.49/16
	19	3.12/16	3.24/16	3.56/16	4.00/16	4.50/16	4.97/16	5.34/16	5.55/16	5.57/16	5.42/16	5.17/16	4.96/16	4.87/16
	21	2.98/16	3.08/16	3.37/16	3.76/16	4.19/16	4.58/16	4.87/16	5.01/16	4.99/16	4.82/16	4.58/16	4.36/16	4.27/16
15	9	0.94/ 7	1.01/ 7	1.21/ 8	1.66/13	2.69/14	4.03/14	5.30/14	6.29/14	6.92/17	7.23/17	7.36/17	7.42/17	7.44/17
	11	1.29/ 9	1.36/ 9	1.63/10	2.26/15	3.47/15	4.94/15	6.30/15	7.34/15	7.98/17	8.25/17	8.30/17	8.29/17	8.28/17
	13	1.65/12	1.76/13	2.12/15	2.84/15	3.99/16	5.33/16	6.54/16	7.45/16	7.97/17	8.13/17	8.07/17	7.96/17	7.92/17
	15	2.07/15	2.20/15	2.60/15	3.28/16	4.26/16	5.36/16	6.34/16	7.06/16	7.44/17	7.48/17	7.33/17	7.15/17	7.08/17
	17	2.36/16	2.49/16	2.87/16	3.46/16	4.27/16	5.14/16	5.91/16	6.45/16	6.70/17	6.67/17	6.46/17	6.25/17	6.16/17
	19	2.45/16	2.57/16	2.91/16	3.42/16	4.08/16	4.78/16	5.38/16	5.7[illegible]/16	5.94/17	5.86/17	5.63/17	5.40/17	5.31/17
	21	2.39/16	2.50/16	2.80/16	3.24/16	3.79/16	[illegible].36/16	4.84/16	5.14/16	5.24/17	5.13/17	4.89/17	4.67/17	4.59/17
20	9	0.84/ 7	0.90/ 7	1.14/ 7	2.19/13	3.81/13	5.43/13	6.77/19	7.71/19	8.18/19	8.17/19	7.79/19	7.39/19	7.23/19
	11	1.12/ 8	1.19/ 8	1.49/ 9	2.62/15	4.30/15	5.97/19	7.35/19	8.31/19	8.78/19	8.75/19	8.34/19	7.89/19	7.71/19
	13	1.35/10	1.45/11	1.84/15	2.91/16	4.42/16	5.92/19	7.15/19	7.99/19	8.37/19	8.29/19	7.85/19	7.37/19	7.18/19
	15	1.62/15	1.76/15	2.18/16	3.10/16	4.36/16	5.61/16	6.63/19	7.30/19	7.57/19	7.44/19	6.99/19	6.51/19	6.31/19
	17	1.86/16	2.00/16	2.41/16	3.17/16	4.19/16	5.20/16	6.01/19	6.53/19	6.70/19	6.53/19	6.09/19	5.63/19	5.44/19
	19	1.98/16	2.10/16	2.47/16	3.11/16	3.93/17	4.74/17	5.38/19	5.77/19	5.87/19	5.68/19	5.26/19	4.83/19	4.65/19
	21	1.97/16	2.09/16	2.41/16	2.94/17	3.62/17	4.28/17	4.79/19	5.08/19	5.13/19	4.93/19	4.55/19	4.16/19	3.99/19
25	9	0.75/ 6	0.81/ 6	1.11/12	3.71/17	6.46/17	8.73/17	10.43/17	11.48/17	11.84/17	11.51/17	10.52/17	9.39/17	8.92/17
	11	0.98/ 7	1.04/ 8	1.42/15	3.65/17	6.18/17	8.31/17	9.91/17	10.90/17	11.25/17	10.93/17	10.01/17	8.94/17	8.50/17
	13	1.14/ 9	1.24/10	1.69/16	3.48/17	5.61/17	7.44/17	8.82/17	9.67/17	9.95/17	9.65/17	8.82/17	7.87/17	7.47/17
	15	1.32/15	1.45/15	1.93/16	3.33/17	5.06/17	6.57/17	7.71/17	8.40/17	8.61/17	8.32/17	7.57/17	6.73/17	6.38/17
	17	1.31/16	1.65/16	2.10/16	3.20/17	4.58/17	5.81/17	6.73/17	7.28/17	7.41/17	7.12/17	6.46/17	5.72/17	5.40/17
	19	1.62/16	1.76/16	2.16/17	3.03/17	4.14/17	5.14/17	5.88/17	6.31/17	6.39/17	6.11/17	5.52/17	4.87/17	4.59/17
	21	1.65/16	1.77/17	2.12/17	2.83/17	3.74/17	4.55/17	5.16/17	5.49/17	5.53/17	5.27/17	4.74/17	4.17/17	3.92/17

Table 17. Example of vertical velocity at a point RSV table.

DD965 NUSC SONAR STUDY (ARMORED, TRIMMED BY BOW .22' OA) 5/13/85 TRA

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 12.00 FEET

HELO DECK BULLSEYE XFP = 14.40 YCL = 0.00 ZBL = 51.00

VERTICAL VELOCITY
(FEET/SEC)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	9	1.78/10	1.93/10	2.29/10	2.71/ 9	3.07/ 9	3.32/ 8	3.41/ 8	3.33/ 8	3.10/ 9	2.73/ 9	2.31/10	1.94/10	1.78/10
	11	2.07/11	2.17/11	2.42/11	2.73/11	3.01/10	3.20/10	3.27/10	3.21/10	3.02/10	2.75/11	2.43/11	2.18/11	2.07/11
	13	2.20/13	2.27/13	2.44/13	2.65/13	2.86/12	3.00/12	3.05/12	3.01/12	2.87/12	2.67/13	2.45/13	2.27/13	2.20/13
	15	2.21/14	2.26/14	2.38/14	2.53/14	2.68/14	2.78/14	2.82/14	2.79/14	2.69/14	2.54/14	2.38/14	2.26/14	2.21/14
	17	2.16/16	2.19/16	2.28/16	2.39/16	2.50/15	2.58/15	2.61/15	2.58/15	2.51/15	2.40/16	2.28/16	2.19/16	2.16/16
	19	2.07/17	2.10/17	2.16/17	2.25/17	2.33/17	2.39/17	2.41/17	2.39/17	2.33/17	2.25/17	2.17/17	2.10/17	2.07/17
	21	1.98/18	2.00/18	2.05/18	2.11/18	2.18/18	2.22/18	2.24/18	2.22/18	2.18/18	2.12/18	2.05/18	2.00/18	1.98/18
5	9	2.01/ 9	2.15/ 9	2.48/ 8	2.85/ 8	3.16/ 8	3.34/ 8	3.36/ 8	3.22/ 8	2.92/ 9	2.49/ 9	2.01/10	1.58/11	1.40/12
	11	2.33/10	2.41/10	2.64/10	2.90/10	3.11/10	3.24/10	3.23/10	3.10/10	2.84/11	2.49/12	2.11/13	1.81/13	1.68/13
	13	2.45/11	2.51/11	2.65/11	2.83/11	2.97/11	3.05/12	3.03/12	2.91/12	2.69/13	2.42/14	2.14/14	1.92/14	1.84/14
	15	2.45/13	2.49/13	2.58/13	2.70/13	2.79/13	2.84/13	2.81/14	2.70/14	2.53/15	2.32/15	2.11/15	1.95/16	1.89/16
	17	2.38/14	2.40/14	2.47/14	2.54/14	2.61/15	2.63/15	2.59/15	2.50/16	2.36/16	2.20/17	2.04/17	1.92/17	1.88/17
	19	2.27/16	2.29/16	2.34/16	2.39/16	2.43/16	2.44/17	2.40/17	2.32/17	2.21/18	2.08/18	1.95/18	1.86/19	1.83/19
	21	2.16/17	2.17/17	2.20/17	2.24/18	2.27/18	2.27/18	2.23/18	2.17/19	2.07/20	1.96/20	1.86/20	1.79/20	1.77/20
10	9	2.12/ 8	2.27/ 8	2.62/ 8	2.99/ 8	3.27/ 8	3.42/ 8	3.39/ 8	3.18/ 8	2.82/ 8	2.33/10	1.78/10	1.30/13	1.09/13
	11	2.50/ 9	2.59/ 9	2.81/ 9	3.06/ 9	3.25/ 9	3.32/10	3.26/10	3.05/10	2.72/11	2.30/13	1.87/15	1.51/15	1.37/15
	13	2.66/10	2.71/10	2.85/10	3.00/10	3.11/11	3.13/11	3.05/12	2.86/12	2.58/14	2.24/15	1.90/16	1.64/17	1.54/17
	15	2.66/12	2.69/12	2.78/12	2.87/12	2.92/12	2.91/13	2.82/14	2.65/15	2.42/16	2.14/17	1.88/17	1.69/18	1.62/18
	17	2.58/13	2.60/13	2.65/13	2.70/14	2.73/14	2.70/15	2.61/15	2.46/17	2.26/17	2.04/18	1.83/19	1.68/19	1.63/19
	19	2.46/15	2.47/15	2.50/15	2.53/15	2.54/16	2.50/16	2.41/17	2.28/18	2.11/19	1.93/20	1.77/20	1.65/21	1.61/21
	21	2.33/16	2.34/17	2.36/17	2.37/17	2.36/17	2.32/18	2.24/18	2.13/20	1.98/20	1.83/21	1.70/22	1.61/22	1.58/22
15	9	2.37/ 7	2.53/ 7	2.89/ 7	3.26/ 7	3.52/ 7	3.62/ 7	3.53/ 7	3.25/ 8	2.80/ 8	2.24/ 8	1.63/ 9	1.10/17	0.87/17
	11	2.78/ 8	2.88/ 8	3.10/ 8	3.34/ 8	3.49/ 8	3.51/ 9	3.38/ 9	3.09/10	2.68/10	2.19/12	1.68/20	1.28/20	1.12/20
	13	2.93/10	2.99/10	3.12/10	3.25/10	3.32/10	3.29/10	3.14/11	2.87/12	2.51/13	2.10/20	1.70/20	1.40/20	1.29/20
	15	2.92/11	2.95/11	3.02/11	3.09/11	3.11/12	3.05/12	2.89/13	2.65/14	2.35/16	2.01/20	1.69/20	1.46/20	1.38/20
	17	2.81/12	2.83/12	2.87/12	2.90/13	2.89/13	2.81/14	2.66/15	2.45/16	2.19/20	1.91/20	1.65/21	1.48/22	1.41/22
	19	2.67/14	2.68/14	2.70/14	2.71/15	2.68/15	2.59/16	2.45/17	2.27/18	2.04/20	1.81/22	1.61/22	1.47/23	1.42/23
	21	2.52/15	2.53/15	2.53/16	2.53/16	2.49/17	2.40/17	2.28/18	2.11/20	1.92/22	1.72/23	1.55/24	1.44/24	1.40/24
20	9	2.97/ 6	3.11/ 6	3.43/ 6	3.75/ 6	3.94/ 6	3.95/ 6	3.77/ 6	3.39/ 6	2.85/ 6	2.20/ 6	1.53/13	0.95/19	0.69/19
	11	3.42/ 6	3.49/ 6	3.67/ 6	3.84/ 6	3.92/ 6	3.84/ 8	3.61/ 8	3.22/ 9	2.70/10	2.12/10	1.54/19	1.09/23	0.91/23
	13	3.47/ 9	3.52/ 9	3.61/ 9	3.69/ 9	3.69/ 9	3.57/10	3.32/10	2.96/11	2.50/13	2.01/19	1.54/23	1.20/23	1.07/23
	15	3.37/10	3.39/10	3.43/10	3.45/10	3.41/11	3.27/11	3.03/12	2.71/13	2.31/15	1.90/23	1.53/26	1.27/26	1.17/26
	17	3.18/11	3.19/11	3.21/12	3.20/12	3.13/12	2.99/13	2.77/14	2.48/16	2.15/19	1.80/26	1.50/26	1.29/26	1.22/26
	19	2.98/13	2.99/13	2.99/13	2.96/14	2.88/14	2.74/15	2.54/16	2.28/19	2.00/23	1.71/26	1.46/27	1.30/27	1.24/27
	21	2.79/14	2.79/15	2.77/15	2.74/15	2.65/16	2.52/17	2.34/19	2.12/20	1.87/23	1.63/27	1.42/27	1.29/27	1.24/27
25	9	3.66/ 6	3.78/ 6	4.04/ 6	4.29/ 6	4.40/ 6	4.33/ 6	4.05/ 6	3.57/ 6	2.93/ 6	2.20/17	1.46/17	0.85/17	0.56/17
	11	4.28/ 6	4.33/ 6	4.44/ 6	4.51/ 6	4.47/ 6	4.27/ 6	3.91/ 6	3.39/ 6	2.77/17	2.09/17	1.44/17	0.94/17	0.74/17
	13	4.26/ 6	4.28/ 6	4.31/ 6	4.29/ 6	4.18/ 6	3.94/ 6	3.57/10	3.09/10	2.53/17	1.95/17	1.42/33	1.03/33	0.88/33
	15	4.01/ 9	4.02/ 9	4.01/ 9	3.95/10	3.81/10	3.57/10	3.23/11	2.80/13	2.32/17	1.83/33	1.40/33	1.09/33	0.98/33
	17	3.71/10	3.71/10	3.68/11	3.61/11	3.46/12	3.23/12	2.92/13	2.55/17	2.13/17	1.72/33	1.37/33	1.13/33	1.04/33
	19	3.42/12	3.41/12	3.37/12	3.29/13	3.15/13	2.94/14	2.66/17	2.33/17	1.98/33	1.63/33	1.34/33	1.14/33	1.07/33
	21	3.15/13	3.14/13	3.10/14	3.02/14	2.88/15	2.68/17	2.44/17	2.15/19	1.84/33	1.55/33	1.30/33	1.14/33	1.09/33

Table 18. Example of SMP.INP file.

```
DD965 NUSC SONAR STUDY (ARMORED, TRIMMED BY BOW .22' OA) 5/13/85 TRA
     6     0      2      0      0      0      2
FEET            1.9905      32.17250.00001279
  529.0000     54.9000     20.3300   8282.00    25.0000     5.0000    0.0000
    3.1700      0.0000     23.1700    0.2500     0.4150     0.2500
   22     0
    0.2500      8      0
    0.2500    0.00    7.20    8.50    6.40    0.90    0.30    0.55    1.05
    0.2500   -9.42   -7.12   -4.12   -0.12    3.88    7.88   13.88   20.33
    0.7500      8      0
    0.7500    0.00    7.10    9.70    7.30    2.60    1.50    2.00    2.65
    0.7500   -9.51   -8.11   -4.11   -0.11    3.89    7.89   13.89   20.33
    1.2500      8      0
    1.2500    0.00    5.60    6.45    3.45    2.40    2.70    3.50    4.30
    1.2500   -7.60   -6.10   -3.10   -0.10    3.90    7.90   13.90   20.33
    2.0000      8      0
    2.0000    0.00    0.25    0.75    3.00    4.50    5.40    6.10    6.75
    2.0000   -4.04   -2.09   -0.09    3.91    7.91   11.91   15.91   20.33
    3.0000      8      0
    3.0000    0.00    2.45    3.45    4.90    6.90    8.20    9.15   10.00
    3.0000   -0.08    0.92    1.92    3.92    7.92   11.92   15.92   20.33
    4.0000      8      0
    4.0000    0.00    3.55    5.00    6.85    9.45   11.05   12.20   13.25
    4.0000   -0.07    0.93    1.93    3.93    7.93   11.93   15.93   20.33
    5.0000      8      0
    5.0000    0.00    4.50    6.35    8.85   12.00   13.90   15.25   16.40
    5.0000   -0.06    0.94    1.94    3.94    7.94   11.94   15.94   20.33
    6.0000      8      0
    6.0000    0.00    5.50    7.75   10.95   14.55   16.80   18.25   19.40
    6.0000   -0.04    0.96    1.96    3.96    7.96   11.96   15.96   20.33
    7.0000      8      0
    7.0000    0.00    6.50    9.35   13.10   17.25   19.65   21.10   22.10
    7.0000   -0.03    0.97    1.97    3.97    7.97   11.97   15.97   20.33
    8.0000      8      0
    8.0000    0.00    7.35   10.80   15.20   19.90   22.30   23.70   24.55
    8.0000   -0.02    0.98    1.98    3.98    7.98   11.98   15.98   20.33
    9.0000      8      0
    9.0000    0.00    8.15   15.00   19.00   22.40   24.65   25.80   26.45
    9.0000   -0.01    0.99    2.99    4.99    7.99   11.99   15.99   20.33
   10.0000      8      0
   10.0000    0.00    8.70   16.35   20.65   24.10   26.25   27.10   27.45
   10.0000    0.00    1.00    3.00    5.00    8.00   12.00   16.00   20.33
   11.0000      8      0
   11.0000    0.00    8.80   16.80   21.25   24.65   26.70   27.45   27.50
   11.0000    0.01    1.01    3.01    5.01    8.01   12.01   16.01   20.33
   12.0000      8      0
   12.0000    0.00    7.90   15.80   20.25   23.95   26.40   27.30   27.50
   12.0000    0.02    1.02    3.02    5.02    8.02   12.02   16.02   20.33
   13.0000     10      0
   13.0000    0.00    1.00    2.25    7.60   15.30   19.60   23.40   25.45   26.75   27.25
   13.0000    0.03    0.50    1.00    2.03    4.03    6.03    9.03   12.03   16.03   20.33
   14.0000     10      0
   14.0000    0.00    0.50    1.00    1.00    8.00   15.70   19.90   22.50   24.75   26.65
   14.0000    0.04    0.05    0.24    1.04    4.04    6.04    8.04   10.04   13.04   20.33
```

Table 18. (Continued)

```
15.0000   10     0
15.0000   0.00    0.50   1.00   1.00   1.00   1.00   6.00  15.40  23.35  25.90
15.0000   0.06    0.07   0.26   2.06   3.06   4.06   6.06   8.06  13.06  20.33
16.0000    8     0
16.0000   0.00    6.40  12.35  18.00  21.35  23.10  24.10  25.00
16.0000   7.82    8.57   9.57  11.07  13.07  15.07  17.07  20.33
17.0000    8     0
17.0000   0.00    7.00  13.55  17.40  19.50  21.00  22.70  24.00
17.0000  10.08   11.08  12.08  13.08  14.08  15.08  17.08  20.33
18.0000    8     0
18.0000   0.00    5.45  12.40  16.95  19.40  20.80  21.75  22.95
18.0000  12.44   13.09  14.09  15.09  16.09  17.09  18.09  20.33
19.0000    8     0
19.0000   0.00    3.80   8.30  12.65  16.00  18.00  20.00  21.80
19.0000  14.80   15.10  15.60  16.10  16.60  17.10  18.10  20.33
19.7500    8     0
19.7500   0.00    6.00   9.10  12.75  16.00  18.00  19.30  20.80
19.7500  16.51   16.86  17.11  17.36  17.61  17.96  18.61  20.33
      1
      6       8.0000    13.0662     3.0000
 8.0000      20.5000     8.7300    40.0000
 9.0000      21.1800     6.6500    51.0000
10.0000      21.5600     5.5850    59.0000
11.0000      21.7500     5.3400    58.0000
12.0000      21.5800     5.8900    58.0000
13.0000      21.0000     7.0300    56.0000
      1
12.5000      15.5364    15.5388     0.0000     0.0250     0.0500     6.7375
      1
19.3290      19.8580    11.0000    16.4300    16.3600
19.4140      19.7640    11.0000     2.3500     2.3600
      2
18.3890      18.5104    17.2500    15.8900    16.0900
18.3780      18.5310    12.7500     4.0900     4.0900
18.3890      18.5104     2.2500    13.4800    13.8200
16.7625      16.8431    15.5000    11.9900    12.1700
16.7433      16.8601    12.7500     6.5800     6.4100
16.7625      16.8431     6.7500    11.0300    11.4900
      0      0     0
      2      1
      1       BRIDGE STBD SIDE                                   5.5000   -15.0000   62.0000
      2       HELO DECK BULLSEYE                                14.4000     0.0000   51.0000
      2      1
      1       SONAR DOME               1         0.8000          0.0000    -9.5000   12.1000
      2       STERN PORT SIDE          3        19.8000         20.8000    33.0000   12.1000
      1          2.0000SIGNIFICANT
12.0000
STOP
```

Table 19. DD-965 computer-generated hydrostatics.

DD965 NUSC SONAR STUDY (ARMORED, TRIMMED BY BOW .22' OA) 5/13/85 TRA

TABLE OF SHIP PARTICULARS

SHIP CHARACTERISTICS -

SHIP LENGTH (LPP)	529.00 FEET	LENGTH/BEAM	9.636
BEAM AT MIDSHIPS	54.90 FEET	BEAM/DRAFT	2.700
DRAFT AT MIDSHIPS	20.33 FEET	DRAFT/BEAM	0.370
DISPLACEMENT (S.W.)	8282.1 L. TONS	DISPL/(.01LPP)**3	55.946
DESIGN SHIP SPEED	25.00 KNOTS	FROUDE NUMBER	0.324

VERTICAL LOCATIONS -

C. OF GRAVITY (VCG)*	2.84 FEET	VCG/BEAM	0.052
C. OF GRAVITY (KG)**	23.17 FEET	KG/BEAM	0.422
METACENTRIC HT. (GM)	3.17 FEET	GM/BEAM	0.058
METACENTER (KM)**	26.34 FEET	KM/BEAM	0.480
C. OF BUOYANCY (KB)**	12.19 FEET	KB/BEAM	0.222

LONGITUDINAL LOCATIONS*** -

C. OF GRAVITY (LCG)	272.35 FEET	LCG/LENGTH	0.515
C. OF BUOYANCY (LCB)	272.35 FEET	LCB/LENGTH	0.515
C. OF FLOTATION (LCF)	304.49 FEET	LCF/LENGTH	0.576

MOTION CHARACTERISTICS -

ROLL GYRADIUS	22.78 FEET	RG/BEAM	0.415
PITCH GYRADIUS	132.25 FEET	PG/LPP	0.250
YAW GYRADIUS	132.25 FEET	YG/LPP	0.250
ESTIMATED ROLL PERIOD	15.86 SECONDS	ROLL FREQ (RADIANS)	0.396

COMPUTED AREAS -

WATERPLANE	21360.4 SQ. FEET	AWP/(LPP*BEAM)	0.735
WETTED SURFACE, HULL	33382.2 SQ. FEET	WS/(2LD+2BD+LB)	0.632

HULL COEFFICIENTS -

BLOCK (CB)	0.491
SECTION (CX)	0.842
PRISMATIC (CP)	0.582

* WATERLINE REFERENCE
** KEEL REFERENCE
***F.P. REFERENCE

Table 20. Example of response amplitude operator magnitudes and phases for the DD-965 6DOF responses.

DD965 NUSC SONAR STUDY (ANCHORED, TRIMMED BY BOW .22' OA) 5/13/85 TRA

RESPONSE AMPLITUDE OPERATORS (RAOS) AND PHASES

SHIP SPEED = 20. KNOTS
SHIP HEADING = 45. DEGREES

SEA STATE: SIGNIFICANT WAVE HEIGHT =12.00 FEET
MODAL PERIOD = 9. SECONDS
STATISTIC = 2.00 (SIGNIFICANT)

OMEGA	OMEGAE	SURGE		SWAY		HEAVE		ROLL		PITCH		YAW	
		AMPL.	PHASE	AMPL.	PHASE	AMPL.	PHASE	AMPL.	PHASE	AMPL.	PHASE	AMPL.	PHASE
0.200	0.230	1.8129E-01	136.1	3.4970E-01	-91.5	9.8954E-01	0.1	5.5875E-03	-104.7	2.6339E-03	-94.2	4.0147E-04	-1.6
0.250	0.296	1.0957E-01	123.1	3.1954E-01	-91.1	9.8795E-01	0.1	3.7285E-02	-125.2	6.5164E-03	-94.8	9.5622E-04	0.0
0.220	0.338	9.0217E-02	117.4	3.0960E-01	-90.3	9.8457E-01	0.2	1.4547E-01	-148.5	1.0412E-02	-95.6	1.5064E-03	6.2
0.300	0.367	8.1263E-02	114.5	3.1705E-01	-90.6	9.8129E-01	0.2	4.4744E-01	179.3	1.3871E-02	-96.4	2.6208E-03	11.5
0.320	0.396	7.4142E-02	112.0	3.0126E-01	-93.9	9.7720E-01	0.3	6.6162E-01	128.7	1.8157E-02	-97.2	4.6387E-03	2.3
0.340	0.426	6.8292E-02	109.9	2.5865E-01	-94.4	9.7238E-01	0.4	4.1123E-01	94.3	2.3402E-02	-98.2	4.9474E-03	-6.2
0.360	0.456	6.3258E-02	108.3	2.3078E-01	-93.5	9.6697E-01	0.5	2.6272E-01	77.0	2.9743E-02	-99.3	4.9931E-03	-8.1
0.380	0.487	5.8825E-02	106.8	2.0950E-01	-92.6	9.6118E-01	0.6	1.9587E-01	66.7	3.7329E-02	-100.6	5.1806E-03	-8.1
0.400	0.519	5.4825E-02	105.6	1.9063E-01	-91.8	9.5539E-01	0.8	1.6263E-01	59.4	4.6306E-02	-102.1	5.4389E-03	-7.3
0.420	0.551	5.1129E-02	104.6	1.7310E-01	-91.1	9.5018E-01	1.0	1.4490E-01	53.7	5.6827E-02	-103.8	5.7251E-03	-6.3
0.440	0.584	4.7670E-02	103.7	1.5660E-01	-90.4	9.4643E-01	1.3	1.3532E-01	48.9	6.9038E-02	-105.7	6.0221E-03	-5.1
0.460	0.617	4.4390E-02	102.9	1.4093E-01	-89.8	9.4535E-01	1.6	1.3033E-01	44.8	8.3082E-02	-107.8	6.3180E-03	-3.7
0.480	0.651	4.1237E-02	102.1	1.2598E-01	-89.1	9.4854E-01	2.0	1.2791E-01	41.2	9.9080E-02	-110.2	6.6002E-03	-2.3
0.500	0.686	3.8178E-02	101.3	1.1149E-01	-88.4	9.5816E-01	2.3	1.2672E-01	38.1	1.1712E-01	-112.9	6.8540E-03	-0.8
0.525	0.730	3.4446E-02	100.3	9.4141E-02	-87.4	9.8350E-01	2.6	1.2548E-01	34.8	1.4258E-01	-116.7	7.1063E-03	1.3
0.550	0.775	3.0773E-02	99.2	7.7598E-02	-86.4	1.0303E+00	2.6	1.2319E-01	31.9	1.7112E-01	-121.2	7.2548E-03	3.4
0.575	0.820	2.7122E-02	98.0	6.2167E-02	-85.2	1.1070E+00	1.9	1.1895E-01	29.4	2.0212E-01	-126.6	7.2730E-03	5.6
0.600	0.867	2.3455E-02	96.5	4.8259E-02	-84.0	1.2223E+00	-0.1	1.1250E-01	27.1	2.3416E-01	-132.9	7.1484E-03	7.8
0.625	0.915	1.9755E-02	94.7	3.6166E-02	-82.6	1.3781E+00	-4.0	1.0398E-01	24.8	2.6429E-01	-140.5	6.8791E-03	10.1
0.650	0.964	1.6028E-02	92.7	2.6043E-02	-80.8	1.5547E+00	-10.9	9.3667E-02	22.5	2.8699E-01	-149.6	6.4682E-03	12.5
0.675	1.013	1.2344E-02	90.7	1.7921E-02	-78.5	1.6826E+00	-21.5	8.1888E-02	20.3	2.9526E-01	-160.5	5.9228E-03	15.2
0.700	1.064	8.9105E-03	89.2	1.1709E-02	-75.4	1.6294E+00	-36.2	6.9007E-02	18.1	2.7252E-01	-173.1	5.2570E-03	18.2
0.750	1.168	4.0288E-03	91.1	4.1638E-03	-65.2	7.9083E-01	-73.0	4.2346E-02	13.2	1.5746E-01	160.7	3.7050E-03	25.9
0.800	1.275	1.8369E-03	98.5	1.1795E-03	-45.5	1.2691E-01	-103.9	1.9776E-02	5.5	5.8367E-02	140.4	2.2083E-03	36.8
0.900	1.501	2.9768E-04	114.0	1.1173E-04	21.2	5.0312E-03	22.7	2.3221E-03	-64.6	2.6958E-03	112.6	5.7633E-04	78.4
1.000	1.742	9.2086E-06	149.4	7.3753E-05	-161.6	6.2125E-03	16.1	7.1833E-03	-126.4	1.6619E-04	-67.8	2.5747E-04	133.6
1.100	1.998	4.7132E-06	-77.3	3.8752E-04	-133.4	1.0095E-03	17.2	6.0638E-03	-132.5	3.3554E-04	-76.8	3.9089E-05	-165.8
1.200	2.269	1.1162E-06	-56.0	1.5604E-04	-107.9	2.2889E-05	31.9	1.0124E-03	-120.9	9.2449E-05	-64.8	5.2220E-05	-51.2
1.500	3.170	1.0867E-08	94.5	7.2015E-05	-110.7	6.4197E-06	60.8	9.1686E-04	-110.1	6.6922E-06	109.9	7.7095E-06	166.8
2.000	4.970	7.4912E-09	-113.1	4.1589E-07	83.9	1.5194E-06	-81.2	6.7453E-06	-172.0	1.9962E-06	-85.3	3.3918E-07	63.3

NOTES: 1) VERTICAL RAOS (SURGE,HEAVE,PITCH) ARE LINEAR AND INDEPENDANT OF SEA STATE.
2) LATERAL RAOS (SWAY,ROLL,YAW) ARE NONLINEAR AND CHANGE WITH SEA STATE AND STATISTIC.
3) AMPL. IS IN (PHYS.UNITS/FOOT)**2 AND PHASE IS IN DEGREES.
4) HEADING CONVENTION: 0 DEG=HEAD, 90 DEG=STBD BEAM, 180 DEG=FOLLOWING SEAS.

Table 21. Minimum analysis of ship responses for the DD-965 at a ship speed of 20 knots in bow and stern quartering seas.

MINIMUM ANALYSIS

SEA TYPE = SHORTCRESTED
SIGNIF. WAVE HEIGHT = 12 FEET
MODAL WAVE PERIOD = 9 SECONDS
SHIP SPEED = 20 KNOTS

				ACTH RUN 2 45 DEG (BOW SEAS)		ACTH RUN 3 135 DEG (STERN QUART. SEAS)	
CHAN	NAME	TYPE	UNITS	STDDEV	PEAK	STDDEV	PEAK
1	WAVEHT	DSP	FEET	2.9	-12.6	2.8	-10.8
2	ROLL	ANG	DEG	1.0	-3.7	3.3	10.2
3	PITCH	ANG	DEG	0.8	2.6	0.5	1.5
4	HEAVE	DSP	FEET	2.3	-7.2	1.6	-6.2
5	RELMOT	DSP	FEET	6.0	-19.2	3.6	-13.1
6	VERT	ACC	G-S	0.11	0.35	0.04	0.33
7	VERT	VEL	FPS	1.8	-5.3	1.1	4.0
8	LATE	ACC	G-S	0.03	0.10	0.03	0.17
9	SLATE	ACC	G-S	0.04	-0.16	0.08	-0.24

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APPENDIX A
LISTING OF STH PROGRAM

```
C DECK STH       -  Simulation Time History Program
*       9/1/89    8:35 am

      PROGRAM STH

*                 --------------------------------------------------
*                 |                                                |
*                 |          SIMULATION TIME HISTORY PROGRAM       |
*                 |                                                |
*                 |               for Wave Height and              |
*                 |         the six-degree-of-freedom motions      |
*                 |     SURGE, SWAY, HEAVE, ROLL, PITCH, and YAW   |
*                 |                                                |
*                 |     at  one speed,  one predominant heading,   |
*                 |     and  one sea condition  (identified by     |
*                 |     significant wave height and modal wave     |
*                 |     period).                                   |
*                 |                                                |
*                 |     Either longcrested or shortcrested seas    |
*                 |     can be selected.                           |
*                 |                                                |
*                 |     Wave height at points can be computed      |
*                 |                                                |
*                 |        David Taylor Research Center (DTRC)     |
*                 |                                                |
*                 |                   Code 1561                    |
*                 |                                                |
*                 --------------------------------------------------

C SUBLIST

*     -----------------------------------------------------------------------
*     |                       List of subroutines                           |
*     |                    ------------------------                         |
*     |  no.   name       type                    description               |
*     |---------------------------------------------------------------------|
*     |                                                                     |
*     |   1   ALGRNG     subroutine    Computes area under a spectrum       |
*     |   2   ATAN2D     function      Arctangent function in degrees for   |
*     |                                any quadrant                         |
*     |   3   BRWVSP     subroutine    Computes Bretschneider Wave Spectrum |
*     |   4   CPFIT      subroutine    Cubic non-parametric spline fit for  |
*     |                                complex data                         |
*     |   5   CPLVAL     subroutine    Evaluates a complex non-parametric   |
*     |                                spline                               |
*     |                                                                     |
*     |---------------------------------------------------------------------|
*     |                                                                     |
*     |   6   ELTIME     subroutine    Prints elapsed time                  |
*     |   7   EXP        function      Avoid underflow with F77L EXP routine|
*     |   8   INTRPL     subroutine    Interpolation routine                |
*     |   9   ORGTFN     subroutine    Reads SMP origin file to get 6DOF    |
*     |                                transfer functions                   |
*     |  10   RLITER     subroutine    Reads ROLL transfer functions for    |
*     |                                roll iteration                       |
*     |                                                                     |
*     |---------------------------------------------------------------------|
*     |
```

```
*   |  11   RLITR     subroutine   Performs roll iteration                  |
*   |  12   SCTH      subroutine   Computes longcrested/shortcrested        |
*   |                              time histories                           |
*   |  13   SLENTH    subroutine   Returns location of last non-blank       |
*   |                              character in a string                    |
*   |  14   SPFIT     subroutine   Cubic non-parametric spline fit for      |
*   |                              real data                                |
*   |  15   SPLVAL    subroutine   Evaluates a real non-parametric          |
*   |                              spline                                   |
*   |                                                                       |
*   |-----------------------------------------------------------------------|
*   |                                                                       |
*   |  16   TFNFIT    subroutine   Fits lateral transfer functions for      |
*   |                              non-linear roll answer                   |
*   |  17   TRFN      subroutine   Transfer function subroutine             |
*   |  18   UCASE     subroutine   Converts strings to uppercase            |
*   |                                                                       |
*   -------------------------------------------------------------------------

C DIMENSIONS

      COMMON DUMMY,US,CS,IvS,IvuS,PAGE,ECS,BELL,DISP,
     2 CLR,YS,NS,N,Samplerate,Dt,Runnumber,Waveheight,Heading,
     2 TrialS,DateS,TimeS,LocationS,PersonnelS,
     2 NameS,Factor(32),UnitsS,
     2 CommentsS,Count,B,Plimit,Nlimit,Nparam,
     2 Results(32,4),Dindx(32,2),FIS,SMPDATAS,STHDATAS,DATAS,
     2 SHIPTYPS,SHIPS,VARIANTS,CYCLES,LSHIP,LDATAS,LSTHDATA,LSMPDATA
      CHARACTER*80 FIS,SMPDATAS,STHDATAS,DATAS
      CHARACTER*8 SHIPTYPS,SHIPS
      CHARACTER VARIANTS*1,CYCLES*2
      INTEGER Dindx
      COMMON /DTITL/ DtitleS
      CHARACTER*72 DtitleS
      COMMON /BK1/ SCRMS(10),NMAX
      COMMON /BK2/ UNTCONV,VKMETR
      COMMON /SINCOS/ SI(0:3600),CO(0:3600),XJTX,RDX,DRX,X2PI
      COMMON /EMA/ EIC,ESPEED,EHEAD,ESIGWH,ETMODAL,STATIS,
     2 ESTART,EEND,NWW,NMU,CHDNG(11),B2(11),EWE(150,11),
     2 COEFR(10,150,11),COEFI(10,150,11)
      COMMON /WAVEPNT/ NWPOINT,WPNTXLOC,WPNTYLOC,WPNTZLOC,WPNTNAMES,
     2 WAVEXLOC,WAVEYLOC,WAVEZLOC
      DIMENSION WPNTXLOC(3),WPNTYLOC(3),WPNTZLOC(3),WAVEXLOC(3),
     2 WAVEYLOC(3),WAVEZLOC(3)
      CHARACTER WPNTNAMES(3)*20

      CHARACTER*4 US,CS,IvS,IvuS,OptionS,AS,UPCS
      CHARACTER YS,NS,ECS,BELL,DISP*8,PAGE*2,CLR*2
      CHARACTER*18 DateS,TimeS,NameS(32),UnitsS(32)
      CHARACTER*40 TrialS,LocationS,PersonnelS,CommentsS
      CHARACTER*3 MONTHS(12)
      CHARACTER*13 DTGS
      CHARACTER*20 T1S,T2S
      CHARACTER*8 ARUN,SUNITS
      CHARACTER*4 TITLE(20),VALS
      CHARACTER*2 SEATYPES,STYPS(2),SMPUTS
      CHARACTER*18 STYPNS(2)

      DIMENSION OMG(30),RLANG(8)
      REAL LPP,KG,KROLL,LCB
```

```
      LOGICAL VRT,LAT,ADDRES

      DATA MONTHS /'JAN','FEB','MAR','APR','MAY','JUN','JUL', AUG',
     2 'SEP','OCT','NOV','DEC'/

C CONSTANTS

*-----------------------------------------------------------------------
*                    Set up program constants

      YS='Y'              ! "YES" answer
      NS='N'              ! "NO"  answer
      Nparam=4            ! No. of statis. param. (MEAN, STDDEV, MAX, MIN)
      NMAX=10             ! Max. no. of channels
      FTMETR=.3048        ! Feet to meters conversion factor
      VKMETR = 1.689*FTMETR    ! FPS to MPS conversion factor
      STYPS(1)='LC'       ! Longcrested  seas
      STYPS(2)='SC'       ! Shortcrested seas
      STYPNS(1) = 'LONGCRESTED  SEAS '
      STYPNS(2) = 'SHORTCRESTED SEAS '

*-----------------------------------------------------------------------
*    Generate sin and cosine lookup table (0.1 deg resolution)

      PI = 3.1415927
      X2PI = 2 * PI
      XJTX = 3600
      RDX = 3600 / X2PI
      DRX = 1 / RDX
      DO 10 J=0,3600
      ARG = J * DRX
      SI(J) = SIN(ARG)
      CO(J) = COS(ARG)
   10 CONTINUE

C START

*  set underflow to zero
*     CALL UNDERO (.TRUE.)
      CALL UNDFL (.TRUE.)

*-----------------------------------------------------------------------
*                    Open STH.INP file

      FIS = 'STH.INP'
      OPEN (5,FILE=FIS,STATUS='OLD')

1000  FORMAT (A)

      READ (5,1000) SMPDATAS
      READ (5,1000) STHDATAS
      READ (5,1000) SHIPTYPS
      READ (5,1000) SHIPS
      READ (5,1000) VARIANTS
      READ (5,1000) CYCLES
      READ (5,1000) SUNITS
      READ (5,1000) TRIALS
```

```
      CALL SLENTH (SMPDATAS,LSMPDATA)
      CALL SLENTH (STHDATAS,LSTHDATA)
      CALL SLENTH (SHIPS,LSHIP)
      CALL SLENTH (SUNITS,LSUNITS)
      CALL UCASE  (SUNITS,LSUNITS)

*-----------------------------------------------------------------------
*    Read point locations for wave height at a point

      READ (5,1000) AS
      READ (5,'(18X,I5)') NWPOINT
      IF (NWPOINT .GT. 3) NWPOINT = 3
      READ (5,1000) AS
      READ (5,1000) AS
      READ (5,1000) AS
      IF (NWPOINT .GT. 0) THEN
        DO 20 I=1,NWPOINT
        READ (5,'(I4,3F8.1,3X,A20)') IWPNT,WPNTXLOC(I),WPNTYLOC(I),
     2  WPNTZLOC(I),WPNTNAMES(I)
   20   CONTINUE
      END IF
      READ (5,1000) AS



*-----------------------------------------------------------------------
*    Open file of origin motion transfer functions from SMP

      FIS = SMPDATAS(1:LSMPDATA)//'\'//
     2 SHIPS(1:LSHIP)//VARIANTS(1:1)//'.ORG'
      OPEN (11,FILE=FIS,FORM='UNFORMATTED',STATUS='OLD')

*                     Read header record
      READ (11) TITLE,NVK,NNMU,NOMEGA,OMG,NRANG,RLANG,VRT,LAT,
     2 ADDRES,LPP,BEAM,DRAFT,DISPLM,GM,DELGM,KG,KROLL,LCB,GRAV,RHO,
     2 VKDES,VKINC,DBLWL

      SMPUTS = 'M'    ! SMP displacement units are in meters
      IF (GRAV .GT. 15.) SMPUTS = 'F'     ! SMP displacement units
*                                           are in feet

      IF (SUNITS(1:1) .NE. 'M') VKMETR = VKMETR/FTMETR
      UNTCONV = 1          ! displacement units conversion factor
      IF (SMPUTS(1:1) .EQ. 'M' .AND. SUNITS(1:1) .EQ. 'F')
     2 UNTCONV = 1./FTMETR
      IF (SMPUTS(1:1) .EQ. 'F' .AND. SUNITS(1:1) .EQ. 'M')
     2 UNTCONV = FTMETR

      GRAV = GRAV * UNTCONV
      LPP = LPP * UNTCONV
      LCB = LCB * UNTCONV     !  Note that LCG = LCB in the SMP program
      DBLWL = DBLWL * UNTCONV

      WRITE (TRIALS,'(10A4)') (TITLE(I),I=1,10)
      CLOSE (11)

      IF (NWPOINT .GT. 0) THEN
        DO 30 I=1,NWPOINT
        WAVEXLOC(I) = LCB - WPNTXLOC(I) * (LPP / 20)
        WAVEYLOC(I) = WPNTYLOC(I)
        WAVEZLOC(I) = 0
```

```
   30   CONTINUE
      END IF

*------------------------------------------------------------------
*                      Start loop over runs

      READ (5,*) NRUNS

*------------------------------------------------------------------
*                      Start loop over runs

      DO 500 IR=1,NRUNS

      READ (5,*) RUNNUMBER,SAMPLERATE,TSTART,TEND,SPEED,HEAD,SIGWH,
     2 TMODAL,STATIS,SEATYPES

      DT=1./Samplerate
      TLRUN=TEND-TSTART
      ICOUNT=Samplerate*TLRUN + 1
      COUNT=ICOUNT

      VK=SPEED

      IC=1
      IF (SEATYPES(1:1).EQ.'L' .OR. SEATYPES(1:1).EQ.'l') IC=1
      IF (SEATYPES(1:1).EQ.'S' .OR. SEATYPES(1:1).EQ.'s') IC=2

      EIC=IC               ! SEA TYPE - 1=Longcrested, 2=Shortcrested
      ESPEED=SPEED         ! Ship speed in knots
      EHEAD=HEAD           ! Predominant heading in degrees
*                            SMP output heading reference
*                            (   0 deg=head, 90 deg=stbd beam,
*                              180 deg=following )
      ESIGWH=SIGWH         ! Significant wave height
      ETMODAL=TMODAL       ! Modal wave period
      ESTART=TSTART        ! Start of run in seconds
      EEND=TEND            ! End of run in seconds
      NWW=150              ! No. of frequencies for time histories
      IF (IC.EQ.1) NMU=1   ! No. of component headings (longcr.  seas)
      IF (IC.EQ.2) NMU=11  ! No. of component headings (shortcr. seas)

*---------------------------------------------------------------
*                       Define the run

      IRUN=RUNNUMBER
      WRITE (ARUN,'(I6)') IRUN
      L=LEN(ARUN)
      M=0
      DO 40 I=1,L
      IF (ARUN(I:I).EQ.CHAR(32)) GO TO 40
      M=I
      GO TO 50
   40 CONTINUE
   50 DATAS='SR'//ARUN(M:L)
      CALL SLENTH (DATAS,LDATAS)

      Waveheight=SIGWH
      Heading=HEAD
      ISPEED=VK+.001
```

```
      IHDNG=HEAD+.001
      ITO=TMODAL+.001
      ISTART=TSTART
      IEND=TEND
      WRITE (CommentsS,3000) STYPS(IC),ISPEED,IHDNG,SIGWH,ITO
 3000 FORMAT(A2,'  V=',I3,'  HD=',I4,'  SWH=',F5.1,'  TO=',I3)

      N = 7 + NWPOINT         ! No. of channels -
*                                  Waveht at LCG +
*                                    6DOF motions +
*                                      Waveht at points
      NameS(1)  = 'WAVEHT  '
      UnitsS(1) =  SUNITS
      NameS(2)  = 'SURGE   '
      UnitsS(2) =  SUNITS
      NameS(3)  = 'SWAY    '
      UnitsS(3) =  SUNITS
      NameS(4)  = 'HEAVE   '
      UnitsS(4) =  SUNITS
      NameS(5)  = 'ROLL    '
      UnitsS(5) = 'DEG   '
      NameS(6)  = 'PITCH   '
      UnitsS(6) = 'DEG   '
      NameS(7)  = 'YAW     '
      UnitsS(7) = 'DEG   '
      NameS(8)  = 'WVHTP1'
      UnitsS(8) =  SUNITS
      NameS(9)  = 'WVHTP2'
      UnitsS(9) =  SUNITS
      NameS(10)  = 'WVHTP3'
      UnitsS(10) =  SUNITS


*-------------------------------------------------------------------
*                 Get DATE and TIME

      CALL DATE(DateS)
      CALL TIME(TimeS)
      T1S=TimeS

      READ (DateS,"(I2)") MONTH
      DTGS = DateS(4:5)//TimeS(1:2)//TimeS(4:5)//'L '//MONTHS(MONTH)//
     2 DateS(7:8)

      AS='CLS'
      CALL SYSTEM (AS)

      FIS = STHDATAS(1:LSTHDATA)//'\'//DATAS(1:LDATAS)//'.TEX'
      OPEN (10,FILE=FIS,FORM='FORMATTED',STATUS='UNKNOWN')

      WRITE ( *,2000) DateS,TimeS
      WRITE (10,2000) DateS,TimeS
 2000 FORMAT (24X,'SIMULATION TIME HISTORY PROGRAM'///
     2 32X,'DATE : ',A8/32X,'TIME : ',A8///)

      WRITE ( *,2002) SHIPTYPS
      WRITE (10,2002) SHIPTYPS
 2002 FORMAT (17X,'SHIP TYPE : ',A8)

      WRITE ( *,2004) TRIALS
      WRITE (10,2004) TRIALS
```

```
2004  FORMAT (/17X,'TITLE : ',A40)

      WRITE ( *,2006) SHIPS
      WRITE (10,2006) SHIPS
2006  FORMAT (/17X,'SHIP : ',A5)

      WRITE ( *,2008) VARIANTS
      WRITE (10,2008) VARIANTS
2008  FORMAT (17X,'HULL VARIANT : ',A1)

      WRITE ( *,2010) CYCLES
      WRITE (10,2010) CYCLES
2010  FORMAT (17X,'SMP CYCLE NO : ',A2)

      WRITE ( *,2014) SUNITS
      WRITE (10,2014) SUNITS
2014  FORMAT (/17X,'UNITS : ',A6)

      WRITE ( *,2015) GRAV
      WRITE (10,2015) GRAV
2015  FORMAT (17X,'GRAVITY : ',F9.4)

      WRITE ( *,2016) LPP
      WRITE (10,2016) LPP
2016  FORMAT (17X,'SHIP LENGTH : ',F8.2)

      WRITE ( *,2018) LCB
      WRITE (10,2018) LCB
2018  FORMAT (17X,'LONGITUDINAL CENTER OF GRAVITY (REF FROM FP) : ',
     2 F8.2)

      WRITE ( *,2020) DBLWL
      WRITE (10,2020) DBLWL
2020  FORMAT (17X,'DISTANCE FROM BASELINE TO WATERLINE : ',F8.2)

      WRITE ( *,2022) RUNNUMBER
      WRITE (10,2022) RUNNUMBER
2022  FORMAT (/17X,'RUN NUMBER : ',F5.0)

      WRITE ( *,2025) CommentsS
      WRITE (10,2025) CommentsS
2025  FORMAT (17X,'COMMENT : ',A40)

      WRITE ( *,2026) Samplerate
      WRITE (10,2026) Samplerate
2026  FORMAT (/17X,'SAMPLE RATE :',F8.3,' SAMPLES/SEC')

      WRITE ( *,2027) TSTART
      WRITE (10,2027) TSTART
2027  FORMAT (17X,'START TIME : ',F8.3,' SEC')

      WRITE ( *,2028) TEND
      WRITE (10,2028) TEND
2028  FORMAT (17X,'STOP  TIME : ',F8.3,' SEC')

      WRITE ( *,2029) TLRUN
      WRITE (10,2029) TLRUN
2029  FORMAT (17X,'RUN   TIME : ',F8.3,' SEC')

      WRITE ( *,2030) ICOUNT
      WRITE (10,2030) ICOUNT
2030  FORMAT (17X,'TOTAL NO. OF SAMPLES : ',I8)
```

```
      WRITE ( *,2031) SPEED
      WRITE (10,2031) SPEED
 2031 FORMAT (/17X,'SHIP SPEED : ',F5.2,' KNOTS')

      WRITE ( *,2040) HEAD
      WRITE (10,2040) HEAD
 2040 FORMAT (17X,'PREDOMINANT HEADING : ',F5.0,' DEG'/
     2 /20X,' SMP OUTPUT HEADING REF. : '
     2 /20X,'-------------------------'
     2 /20X,'     0 deg=head seas,          '
     2 /20X,'    90 deg=stbd beam seas,     '
     2 /20X,'   180 deg=following seas     '//)

      WRITE ( *,2045) STYPNS(IC)
      WRITE (10,2045) STYPNS(IC)
 2045 FORMAT (17X,'SEA TYPE :   ',A18)

      WRITE ( *,2050) SIGWH,SUNITS
      WRITE (10,2050) SIGWH,SUNITS
 2050 FORMAT (17X,'SIGNIF. WAVE HEIGHT : ',F6.2,' ',A6)

      WRITE ( *,2060) TMODAL
      WRITE (10,2060) TMODAL
 2060 FORMAT (17X,'MODAL WAVE PERIOD   : ',F6.2,' SEC'/)

      WRITE ( *,2070) STATIS
      WRITE (10,2070) STATIS
 2070 FORMAT (17X,'STATISTIC USED FOR ROLL ITERATION : ',F6.2,
     2 ' * RMS'//)

      WRITE ( *,2075) N
      WRITE (10,2075) N
 2075 FORMAT (17X,'NUMBER OF CHANNELS : ',I3)

      WRITE ( *,2076) NWPOINT
      WRITE (10,2076) NWPOINT
 2076 FORMAT (//17X,'NUMBER OF WAVE POINTS: ',I3//)
      WRITE ( *,2077)
      WRITE (10,2077)
 2077 FORMAT (26X,'List of Wave Points'//10X,
     2 '  NO    XLOC    YLOC    ZLOC         NAME'/12X,51('-'))
      IF (NWPOINT .GT. 0) THEN
        DO 60 I=1,NWPOINT
        WRITE ( *,'(10X,I4,3F7.1,3X,A20)') I,WPNTXLOC(I),
     2  WPNTYLOC(I),WPNTZLOC(I),WPNTNAMES(I)
        WRITE (10,'(10X,I4,3F7.1,3X,A20)') I,WPNTXLOC(I),
     2  WPNTYLOC(I),WPNTZLOC(I),WPNTNAMES(I)
   60   CONTINUE
      END IF

      CALL TRFN       !  Get transfer functions

      CALL SCTH       !  Compute time histories

      WRITE ( *,2080)
      WRITE (10,2080)
 2080 FORMAT (///37X,'STATISTICAL RESULTS'//41X,'TIME DOMAIN',14X,
     2 'FREQ. DOMAIN'/' CHAN   NAME      UNIT',8X,'MEAN',4X,'STDDEV',6X,
     2 'MAX',7X,'MIN',7X,'STDDEV'/)

      DO 70 M=1,N
```

```
      WRITE( *,2090) M,NameS(M),UnitsS(M),(Results(M,J),J=1,4),
     2 SCRMS(M)
      WRITE(10,2090) M,NameS(M),UnitsS(M),(Results(M,J),J=1,4),
     2 SCRMS(M)
 2090 FORMAT (I4,3X,A8,2X,A6,4F10.3,F12.3)
   70 CONTINUE

      CALL TIME (T2S)
      CALL ELTIME (T1S,T2S)

      CLOSE (10)

*----------------------------------------------------------------------
*                   Open STHLOG.TEX file

      FIS = STHDATAS(1:LSTHDATA)//'\'//'STHLOG.TEX'

      OPEN (3,FILE=FIS,STATUS='NEW',ERR=80)

      WRITE (3,"(/27X,'STH LOG RUN SUMMARY')")
      WRITE (3,"(/19X,'TRIAL:   ',A)") TRIALS
      WRITE (3,"(/19X,'STH DATA PATH :    ',A)") STHDATAS(1:LSTHDATA)
      WRITE (3,"(//19X,'TYPE CODE :    BI - BINARY')")
      WRITE (3,"(/'  RUN TYPE   TIME    DATE-TIME-GROUP              '
     2 '    COMMENTS')")

      GO TO 100

   80 OPEN (3,FILE=FIS,STATUS='OLD',ERR=99)

   90 READ (3,1000,ERR=100) AS
      GO TO 90

  100 IF (MOD(RUNNUMBER, 5) .EQ. 1) WRITE (3,*) "    "
      RTIME = TLRUN / 60            ! run time in minutes
      WRITE (3,4000) RUNNUMBER, 'BI', RTIME, ' MIN', DTGS, CommentsS
4000  FORMAT (I5,2X,A2,F6.1,A4,3X,A13,4X,A40)

      CLOSE(3)

* ---------------------------------------------------------------------
*                  End loop over runs

  500 CONTINUE

      CLOSE(5)

C QUIT


      STOP
99   write (*,*) ' error'

      END


C SUBROUTINES
```

```
************************************************************************

C DECK ALGRNG   -  Computes area under a spectrum
*       3/31/88    8:10 am

      SUBROUTINE ALGRNG (N,W,S,AREA)

*   This subroutine computes the area under the curve for a particular
*   spectrum.  An odd number of points (frequencies) should be used.

      DIMENSION W(N),S(N)
      MN=N-2
      AREA=0.
      TEMP = 0.
      DO 20 M=1,MN,2
      A=W(M+2)-W(M)
      B=W(M+2)-W(M+1)
      C=W(M+1)-W(M)
      PAREA = A*A/6.*(S(M)*(3.*C-A)/(A*C)+S(M+1)*A/(B*C)+
     2 S(M+2)*(2.*A-3.*C)/(A*B))
      TEMP = PAREA
      IF (PAREA .LT. 0.) TEMP = 0.
      AREA = AREA + TEMP
20    CONTINUE
      IF (MOD(N,2) .EQ. 1) GO TO 30
      DELW = W(N) - W(N-1)
      DELS = S(N) - S(N-1)
      AREA = AREA + S(N-1)*DELW + .5*DELS*DELW
   30 CONTINUE
      AREA = ABS(AREA)

      RETURN
      END

C DECK ATAN2D   -  Arctangent function in degrees for any quadrant
*       2/18/89    1:15 pm

      FUNCTION ATAN2D (B,A,RADDEG)

*   Arctangent function to compute angles (in degrees) in any quadrant.
*   The b argument is the imaginary vector.  The A argument is the real
*   vector.

      DATA EPS /1.E-6/
      IF (B .EQ. 0.) ATAN2D =  0.
      IF (B .GT. 0.) ATAN2D = 90.
      IF (B .LT. 0.) ATAN2D =-90.
      IF (ABS(A) .GT. EPS) ATAN2D = ATAN2(B,A) * RADDEG

      RETURN
      END

C DECK BRWVSP   -  Computes Bretschneider Wave Spectrum
*       4/2/88    12:30 pm

      SUBROUTINE BRWVSP (NOK,SIGWH,TO,W,S)

*  this routine calculates a BRETSCHNEIDER 2-parameter wave spectrum
*          (significant wave height, modal wave period)
```

```
*                    W.G.MEYERS, DTNSRDC, 072977
      DIMENSION W(NOK),S(NOK)

      EXTERNAL EXP

      DATA A,B /487.0626,1948.2444/
      T04 = T0**4

*    for Pierson-Moskowitz wave spectrum
*        T04 = 58.0936*SIGWH**2

      CON1 = A*SIGWH**2/T04
      CON2 = B/T04
      DO 10 I=1,NOK
      W4 = W(I)**4
      W5 = W(I)*W4
      ARG = CON2/W4
      IF (ARG.GT.50.) S(I)=0.
      IF (ARG.GT.50.) GO TO 10
      S(I) = CON1/W5*EXP(-ARG)
   10 CONTINUE

      RETURN
      END


C DECK CPFIT    -  Cubic non-parametric spline fit for complex data
*      3/31/88    8:15 am

      SUBROUTINE CPFIT (X, Z, CELEMS, NPTS)

*        CPFIT CREATED FROM SPFIT                  E N HUBBLE   JUNE 1977
*     FITS CUBIC NON-PARAMETRIC SPLINE SEGMENTS
*              TO SET OF COMPLEX DATA POINTS
*
*     INPUTS
*        X      =  ARRAY OF REAL INDEPENDENT VARIABLES
*        Z      =  ARRAY OF COMPLEX DEPENDENT VARIABLES
*        NPTS   =  NUMBER OF  (X,Z)  DATA POINTS
*     RETURN
*       CELEMS =  ARRAY OF (NPTS-1) SEGMENTS IN FOLLOWING FORM
*                 ( (Z(I), D(I), Z(I+1), D(I+1) )      ,    WHERE
*           D   =  ARRAY OF SECOND DERIVATIVES AT DATA POINTS

*     ARRAYS A,B,C ARE MAINLY SUB DIAG., DIAGONAL, AND SUPER DIAG.
*     D ARRAY IS THE RIGHT HAND SIDE OF MATRIX EQUATION
*     SECOND DERIVATIVES AT NODES ARE PLACED IN D ARRAY AFTER SOLUTION
*     SOLUTION TECHNIQUE IS GAUSSIAN ELIMINATION
*     BOUNDARY CONDITIONS SET BY EXTRAPOLATION OF SECOND DERIVATIVES

      COMMON/IO/ICARD,IPRIN,POTFIL,COFFIL,RAOFIL,RMSFIL,ORGFIL,SPCFIL,
     2 ISCARD,BLKFIL,SCRFIL,SPLFIL,LCOFIL,LRAFIL,SEVFIL
      INTEGER   ICARD,IPRIN,POTFIL,COFFIL,RAOFIL,RMSFIL,ORGFIL,SPCFIL,
     2 ISCARD,BLKFIL,SCRFIL,SPLFIL,LCOFIL,LRAFIL,SEVFIL
      COMPLEX  Z, ZDD, STORE, D, CELEMS
       DIMENSION X(NPTS),Z(NPTS),CELEMS(4,NPTS)
      DIMENSION A(100), B(100), C(100), D(100)
      N = NPTS
      NL1 = N - 1
      NL2 = N - 2
      DO 50 I=2,N
```

```
      IF (X(I) .GT. X(I-1))  GO TO 50
         WRITE ( *,888) X(I-1),X(I)
         WRITE (10,888) X(I-1),X(I)
         GO TO 88888
50    CONTINUE
      IF (N .LE. 100)  GO TO 100
         WRITE ( *,999)
         WRITE (10,999)
         N = 100
100   CONTINUE
      IF (N .GT. 2)  GO TO 125
         D(1) = (0.0, 0.0)
         D(2) = (0.0, 0.0)
         GO TO 375
125   CONTINUE
      IF (N .GT. 3)  GO TO 150
         ZDD = 2.*((X(3)-X(2))*Z(1)+(X(2)-X(1))*Z(3)-(X(3)-X(1))*Z(2))
     .           /((X(3)-X(2))*(X(2)-X(1))*(X(3)-X(1)))
         D(1) = ZDD
         D(2) = ZDD
         D(3) = ZDD
         GO TO 375
150   CONTINUE
      DO 200 I=1,N
         A(I) = 0.0
         B(I) = 0.0
         C(I) = 0.0
         D(I) = (0.0, 0.0)
200   CONTINUE
*        SET UP MATRICES(A TRIDIAGONAL STRUCTURE)
      A(1) = (X(3)-X(2))/(X(3)-X(1))
      C(1) = 2.0
      B(1) = 1.0 - A(1)
      D(1) = 6.0*((Z(3)-Z(2))/(X(3)-X(2))-(Z(2)-Z(1))/
     1 (X(2)-X(1)))/(X(3)-X(1))
      H = X(3) - X(2)
      DO 250 I=3,NL1
         HP = X(I+1) - X(I)
         C(I) = HP / (H+HP)
         B(I) = 2.0
         A(I) = 1.0 - C(I)
         D(I) = 6.0*((Z(I+1)-Z(I))/HP-(Z(I)-Z(I-1))/H)/(HP+H)
         H = HP
250   CONTINUE
*        SET BOUNDARY CONDITIONS
      C(2) = (X(2)-X(1))/(X(3)-X(2))
      A(2) = 1.0
      B(2) = -1.0-C(2)
      C(2) = -A(2)*A(1)/B(1) + C(2)
      D(2) = (0.0, 0.0)
      C(N) = (X(N)-X(N-1))/(X(N-1)-X(N-2))
      A(N) = -1.0 - C(N)
      B(N) = 1.0
      D(N) = (0.0, 0.0)
*        SOLVE EQUATIONS
      II = 1
      DO 300 I=1,NL2
         I1 = I + 1
         I2 = I + 2
         AUGH = ABS (B(I))
         IF (AUGH .LT. 1.0E-06)  GO TO 275
            CONST = A(I1) / B(I)
```

```
            B(I1) = B(I1) - CONST*C(I)
            D(I1) = D(I1) - CONST*D(I)
         IF (I .NE. NL2)  GO TO 300
            A(N) = A(N) - C(N)*C(I) / B(I)
            D(N) = D(N) - C(N)*D(I) / B(I)
            GO TO 300
275      CONTINUE
            I1 = I + 1
            D(I) = D(I) / C(I)
            D(I1) = D(I1) - B(I1)*D(I)
            B(I1) = A(I1)
            A(I1) = 0.0
            D(I2) = D(I2) - A(I2)*D(I)
            A(I2) = 0.0
         IF (I .NE. NL2)  GO TO 300
            A(N) = C(N)
300   CONTINUE
      DET = B(NL1)*B(N) - C(NL1)*A(N)
      STORE = D(N)
      D(N) = (B(NL1)*D(N) - D(NL1)*A(N)) / DET
      D(NL1) = (D(NL1)*B(N) - C(NL1)*STORE) / DET
      IP = 0
      DO 350 I=2,NL2
         JI = N - I
         IF (JI .EQ. IP)  GO TO 350
         IF (JI .EQ. I1)  GO TO 325
            D(JI) = (D(JI)-C(JI)*D(JI+1))/B(JI)
            GO TO 350
325      CONTINUE
            IP = JI-1
            STORE = D(JI)
            D(JI) = D(IP)
            D(IP) = (STORE - C(IP)*D(JI+1))/B(IP)
350   CONTINUE
      D(1) = (D(1) - A(1)*D(3) - C(1)*D(2)) / B(1)
*        SET UP SPLINE SEGMENTS
375   CONTINUE
      DO 400 I=1,NL1
         I1 = I + 1
         CELEMS(1,I) = Z(I)
         CELEMS(2,I) = D(I)
         CELEMS(3,I) = Z(I1)
         CELEMS(4,I) = D(I1)
400   CONTINUE
99999 CONTINUE
      RETURN
88888 CONTINUE
      STOP
888   FORMAT ('0 CPFIT-- X VALUES NOT ASCENDING', 2E16.8)
999   FORMAT ('0 CPFIT-- NPTS EXCEEDS 100.  ONLY 99 SEGMENTS RETURNED')
      END


C DECK CPLVAL   -  Evaluates a complex non-parametric spline
*        3/31/88     8:15 am

         SUBROUTINE CPLVAL (X, NPTS, CELEMS, X0, Z0, S0, IELM)

*          CPLVAL CREATED FROM SPLVAL
*        EVALUATES A COMPLEX NON-PARAMETRIC SPLINE

*        INPUTS
```

```
*          X      =  ARRAY OF REAL INDEPENDENT VARIABLES
*          NPTS   =  NUMBER OF VALUES IN X-ARRAY
*          CELEMS=  COMPLEX SPLINE SEGMENTS GENERATED BY CPFIT
*          X0     =  X-VALUE AT WHICH SPLINE IS TO BE EVALUATED
*       RETURNS
*          Z0     =  F(X0)  =  Z-VALUE EVALUATED AT X0
*          S0     =  SECOND DERIVATIVE EVALUATED AT X0
*          IELM   =  INDEX OF SPLINE SEGMENT CONTAINING X0

      COMPLEX  CELEMS, Z0, Z1, Z2, S0, S1, S2
       DIMENSION X(NPTS),CELEMS(4,NPTS)
      COMMON/IO/ICARD,IPRIN,POTFIL,COFFIL,RAOFIL,RMSFIL,ORGFIL,SPCFIL,
     2 ISCARD,BLKFIL,SCRFIL,SPLFIL,LCOFIL,LRAFIL,SEVFIL
       INTEGER   ICARD,IPRIN,POTFIL,COFFIL,RAOFIL,RMSFIL,ORGFIL,SPCFIL,
     2 ISCARD,BLKFIL,SCRFIL,SPLFIL,LCOFIL,LRAFIL,SEVFIL
      N = NPTS
      IF (X0.GE.X(1) .AND. X0.LE.X(N))  GO TO 100
       WRITE ( *,999) X0
       WRITE (10,999) X0
         GO TO 99999
100   CONTINUE
      DO 200 I=2,N
         IF (X0 .GT. X(I))  GO TO 200
            GO TO 300
200   CONTINUE
300   CONTINUE
      I = I - 1
      XX = X(I+1) - X(I)
      X1 = X0 - X(I)
      X2 = X(I+1) - X0
      XX6 = XX * XX / 6.0
      Z1 = CELEMS(1,I)
      Z2 = CELEMS(3,I)
      S1 = CELEMS(2,I)
      S2 = CELEMS(4,I)
      Z0 =   (S1 * X2**3 + S2 * X1**3) / (6.0 * XX)  +
     .      ( (Z1 - S1*XX6) * X2 + (Z2 - S2*XX6) * X1 ) / XX
      S0 = (S1 * X2  +  S2 * X1) / XX
      IELM = I
      RETURN
99999 CONTINUE
      STOP
  999 FORMAT ('0 EXTRAPOLATION NOT ALLOWED.  X0 =', E16.8)
      END


C DECK ELTIME   -  Prints elapsed time
*        3/31/88     8:30 am

        SUBROUTINE ELTIME (TS,ES)

        CHARACTER*20 TS,ES

        READ (TS,'(I2,1X,I2,1X,F5.2)') IH,IM,BSEC
        READ (ES,'(I2,1X,I2,1X,F5.2)') JH,JM,ESEC

        IF (ESEC .GE. BSEC) GO TO 10
        ESEC = ESEC + 60.
        JM = JM - 1
   10   IF (JM .GE. IM) GO TO 20
        JM = JM + 60.
        JH = JH - 1
```

```
   20  IF (JH.LT.IH) JH=JH+24

       KH=JH-IH
       KM=JM-IM
       DELSEC=ESEC-BSEC
       KS=DELSEC+.5

       WRITE ( *,1000) KH,KM,KS
       WRITE (10,1000) KH,KM,KS
 1000  FORMAT (//29X,"ELAPSED TIME"/16X,39("-")/
     2 17X,I3," Hours",2X,I3, " Minutes",2X,I3," Seconds")

       RETURN
       END


C DECK EXP       -  Avoid underflow with F77L EXP routine
*      4/2/88     2:40 pm

       FUNCTION EXP(X)

*  avoid underflow with F77L EXP routine

       IF(X.LT.(-50))THEN
         EXP=0.
       ELSE
         EXP=DEXP(X)
       ENDIF

       RETURN
       END


C DECK INTRPL    -  Interpolation routine
*      3/31/88    8:30 am

       SUBROUTINE INTRPL(N,XN,YN,M,XM,YM)

       DIMENSION XN(N),YN(N),XM(M),YM(M)
       K=1
       SLOPE=(YN(K+1)-YN(K))/(XN(K+1)-XN(K))
       DO 40 I=1,M
10     IF (XM(I).GE.XN(K+1)) GO TO 20
       YM(I)=YN(K)+SLOPE*(XM(I)-XN(K))
       GO TO 40
20     K=K+1
       IF (K.EQ.N) GO TO 30
       SLOPE=(YN(K+1)-YN(K))/(XN(K+1)-XN(K))
       GO TO 10
30     YM(I)=YN(K)
40     CONTINUE

       RETURN
       END


C DECK ORGTFN    -  Reads SMP origin file to get 6DOF transfer functions
*      2/15/89    9:10 am

       SUBROUTINE ORGTFN (SPEED,NMU,CHDNG,RLANS,RADDEG)

       COMMON /BK2/ UNTCONV,VKMETR
```

```
      COMMON /BK3/ MOTV,MOTL,HJV,HJL,H7,ORGTF,CTEMP
      COMPLEX MOTV(3,30),MOTL(3,30,8),HJV(3,30),HJL(3,30),H7(30)
      COMPLEX ORGTF(30,11,6),CTEMP
      DIMENSION CHDNG(11),OMEGA(30),RLANG(8)
      CHARACTER*4 TITLE(20)
      REAL LPP,KG,KROLL,LCB
      LOGICAL VRT,LAT,ADDRES
      DATA EPS /0.5/

*-----------------------------------------------------------------------
*              Read header record from SMP origin file

      REWIND 11
      READ (11) TITLE,NVK,NNMU,NOMEGA,OMEGA,NRANG,RLANG,VRT,LAT,
     2 ADDRES,LPP,BEAM,DRAFT,DISPLM,GM,DELGM,KG,KROLL,LCB,GRAV,RHO,
     2 VKDES,VKINC,DBLWL

      GRAV = GRAV * UNTCONV
      LPP = LPP * UNTCONV
      LCB = LCB * UNTCONV
      DBLWL = DBLWL * UNTCONV

      ISPEED=0
      IHEAD=0

      DO 200 IV=1,NVK                  ! Loop over ship speed

      DO 190 IH=1,NNMU                 ! Loop over 13 SMP headings

      READ (11) SHPSPD,HEADNG,OMEGAE
      IF (VRT) READ (11) MOTV
      IF (LAT) READ (11) MOTL
      IF (ADDRES) READ (11) HJV,HJL,H7

*-----------------------------------------------------------------------
*                Skip if not desired ship speed

      IF (SHPSPD .GT. SPEED) GO TO 210
      IF (ABS(SHPSPD-SPEED) .GT. EPS) GO TO 190
      ISPEED=1

*-----------------------------------------------------------------------
*                      Loop over plane

*             IP = 1   -   STBD plane headings
*             IP = 2   -   PORT plane headings

      DO 180 IP=1,2                    ! Loop over plane
      IPLANE=IP

*-----------------------------------------------------------------------
*    Determine if this heading is one of the component headings

      KH=0

      DO 130 LH=1,NMU                  ! Loop over component headings
      ARG=CHDNG(LH)
```

```
      GO TO (110,120),IP            ! Select plane (STBD or PORT)

*------------------------------------------------------------------
*                STBD plane headings

  110 IF (ARG.GT.180.) GO TO 130
      IF (ABS(ARG-HEADNG).GT.EPS) GO TO 130
      KH=LH
      GO TO 140

*------------------------------------------------------------------
*                PORT plane headings

  120 IF (ARG.LE.180.) GO TO 130
      ARG=ABS(ARG-360.)
      IF (ABS(ARG-HEADNG).GT.EPS) GO TO 130
      KH=LH
      GO TO 140

  130 CONTINUE                      ! End loop over component headings

      IF (KH.EQ.0) GO TO 180        ! Skip if not a component heading

*------------------------------------------------------------------
*            This is one of the component headings

  140 IHEAD=1
      ARG=CHDNG(KH)

*------------------------------------------------------------------
*          Store 6 DOF origin motion transfer functions


*    Vertical mode motions :  Surge, Heave and Pitch

      DO 150 J=1,3                  ! Loop over motions
      JJ = (J-1)*2 + 1
      DO 150 IW=1,NOMEGA            ! Loop over 30 wave frequencies
      CTEMP=MOTV(J,IW)
      IF (J .EQ. 3) CTEMP = CTEMP * RADDEG / UNTCONV
      ORGTF(IW,KH,JJ)=CTEMP
  150 CONTINUE                      ! End loop over motions and frequencies


*    Lateral mode motions :  Sway, Roll and Yaw

      DO 170 J=1,3                  ! Loop over motions
      JJ = (J-1)*2 + 2
      DO 170 IW=1,NOMEGA            ! Loop over 30 wave frequencies
      CTEMP=(0.,0.)                 ! Head or following seas
      IF (IH.GT.1 .AND. IH.LT.13)
     2 CALL TFNFIT (RLANG,NRANG,RLANS,MOTL,J,IW,CTEMP)
      IF (J .GT. 1) CTEMP = CTEMP * RADDEG / UNTCONV

*      Change polarity of lateral motions for port headings
      IF (IPLANE .EQ. 2) CTEMP = - CTEMP
```

```
      ORGTF(IW,KH,JJ)=CTEMP

  170 CONTINUE                        ! End loops over motion and frequency

  180 CONTINUE                        ! End loop over plane

      IF (NMU .EQ. 1 .AND. IHEAD .EQ. 1) GO TO 220

  190 CONTINUE                        ! End loop over 13 SMP headings

*----------------------------------------------------------------------
*    Skip if this is the correct speed and heading

      IF (ISPEED.EQ.1 .and. IHEAD.EQ.1) GO TO 220

  200 CONTINUE                        ! End loop over ship speed

*----------------------------------------------------------------------

  210 WRITE ( *,1000)
      WRITE (10,1000)
 1000 FORMAT ('  Did not find speed or heading.  Program stopped.')
      STOP

  220 CONTINUE

      RETURN
      END

C DECK RLITER   -  Reads ROLL transfer functions for roll iteration
*     2/15/89      9:10 am

      SUBROUTINE RLITER (SPEED,NMU,B2,CHDNG,STATIS,SWAVE,RADDEG,RLANS)

      COMMON /BK2/ UNTCONV,VKMETR
      COMMON /BK3/ MOTV,MOTL,HJV,HJL,H7,VERTFN,LATTFN,CTEMP
      COMPLEX MOTV(3,30),MOTL(3,30,8),HJV(3,30),HJL(3,30),H7(30)
      COMPLEX VERTFN(3,30,11),LATTFN(3,30,11),CTEMP
      DIMENSION RLCALC(8),B2(11),ROLVAR(8,11),CHDNG(11),RLANG(8)
      DIMENSION OMEGA(30),OMEGAE(30),SWAVE(30),R(30)
      CHARACTER*4 TITLE(20)
      REAL LPP,KG,KROLL,LCB
      LOGICAL VRT,LAT,ADDRES
      DATA EPS /0.5/

*----------------------------------------------------------------------
*                     Read header record

      REWIND 11
      READ (11) TITLE,NVK,NNMU,NOMEGA,OMEGA,NRANG,RLANG,VRT,LAT,
    2 ADDRES,LPP,BEAM,DRAFT,DISPLM,GM,DELGM,KG,KROLL,LCB,GRAV,RHO,
    2 VKDES,VKINC,DBLWL

      GRAV = GRAV * UNTCONV
      LPP = LPP * UNTCONV
      LCB = LCB * UNTCONV
```

```
      DBLWL = DBLWL * UNTCONV

*     WRITE ( *,2000)
*     WRITE (10,2000)
*2000 FORMAT (24X,'   IH  HEAD  ARG    IP   KH'/)

      ISPEED=0
      IHEAD=0


      DO 200 IV=1,NVK                   ! Loop over ship speed

      DO 190 IH=1,NNMU                  ! Loop over 13 SMP headings

      READ (11) SHPSPD,HEADNG,OMEGAE
      IF (VRT) READ (11) MOTV
      IF (LAT) READ (11) MOTL
      IF (ADDRES) READ (11) HJV,HJL,H7


*-----------------------------------------------------------------
*                 Skip if not desired ship speed

      IF (SHPSPD .GT. SPEED) GO TO 210
      IF (ABS(SHPSPD-SPEED) .GT. EPS) GO TO 190
      ISPEED=1


*-----------------------------------------------------------------
*                       Loop over plane

*               IP = 1   -   STBD plane headings
*               IP = 2   -   PORT plane headings

      DO 180 IP=1,2                     ! Loop over plane
      IPLANE=IP


*-----------------------------------------------------------------
*    Determine if this heading is one of the component headings

      KH=0

      DO 130 LH=1,NMU                   ! Loop over component headings
      ARG=CHDNG(LH)

      GO TO (110,120),IP                ! Select plane (STBD or PORT)

*-----------------------------------------------------------------
*                 STBD plane headings

  110 IF (ARG.GT.180.) GO TO 130
      IF (ABS(ARG-HEADNG).GT.EPS) GO TO 130
      KH=LH
      GO TO 140


*-----------------------------------------------------------------
*                 PORT plane headings
  120 IF (ARG.LE.180.) GO TO 130
      ARG=ABS(ARG-360.)
      IF (ABS(ARG-HEADNG).GT.EPS) GO TO 130
```

```
      KH=LH
      GO TO 140

  130 CONTINUE                         !  End loop over component headings

      IF (KH.EQ.0) GO TO 180           ! Skip if not a component heading


*-----------------------------------------------------------------------
*            This is one of the 11 component headings

  140 IHEAD=1
      ARG=CHDNG(KH)

*     WRITE( *,2010) IH,HEADNG,ARG,IP,KH
*     WRITE(10,2010) IH,HEADNG,ARG,IP,KH
*2010 FORMAT (24X,I5,2F6.0,2I5)


*-----------------------------------------------------------------------
*           Store longcrested roll mean square values

      DO 160 IA=1,NRANG                ! Loop over 8 mean roll angles

      DO 150 IW=1,NOMEGA               ! Loop over 30 wave frequencies
      CTEMP=(0.,0.)                    ! Head or following seas
      IF (IH.GT.1 .AND. IH.LT.13) CTEMP=MOTL(2,IW,IA)
      CTEMP=CTEMP/UNTCONV
      R(IW) = CABS(CTEMP)**2 * SWAVE(IW)
  150 CONTINUE                         ! End loop over wave frequencies

      CALL ALGRNG (NOMEGA,OMEGA,R,ROLVAR(IA,KH))

  160 CONTINUE                         ! End loop over mean roll angles

  180 CONTINUE                         ! End loop over plane

      IF (NMU .EQ. 1 .AND. IHEAD .EQ. 1) GO TO 220

  190 CONTINUE                         ! End loop over 13 SMP headings


*-----------------------------------------------------------------------
*   Skip if this is the correct speed and heading

      IF (ISPEED.EQ.1 .and. IHEAD.EQ.1) GO TO 220


  200 CONTINUE                         !  End loop over ship speed


*-----------------------------------------------------------------------

  210 WRITE ( *,1000)
      WRITE (10,1000)
 1000 FORMAT ('  Did not find speed or heading.  Program stopped.')
      STOP


*-----------------------------------------------------------------------
*                      Roll Iteration
```

```
  220   DO 240 IA=1,NRANG                ! Loop over 8 mean roll angles

        RLCALC(IA) = 0

        DO 230 IH=1,NMU                  ! Loop over component headings
        RLCALC(IA) = RLCALC(IA) +  B2(IH)**2 * ROLVAR(IA,IH)
  230   CONTINUE                         ! End loop over component headings

        RLCALC(IA) = STATIS * SQRT(RLCALC(IA)) * RADDEG

  240   CONTINUE                         ! End loop over mean roll angles

        CALL RLITR (RLANG,NRANG,RLCALC,RLANS)

*       IF (RLANS.EQ.0.) STOP

        RETURN
        END


C DECK RLITR     -  Performs roll iteration
*       3/31/88     8:40 am

        SUBROUTINE RLITR (RLANG,NRANG,RLCALC,RLANS)

        DIMENSION RLANG(8),RLCALC(8),DIFF(8),ELM(4,8)

        DO 10 IA=1,NRANG         !  Loop over 8 mean roll angles
        DIFF(IA) = RLANG(IA) - RLCALC(IA)
   10   CONTINUE

        X0 = 0.
        IF (X0 .GE. DIFF(1)) GO TO 20
        RLANS = RLCALC(1)
        GO TO 40
   20   IF (X0 .LE. DIFF(NRANG)) GO TO 30
        RLANS = RLCALC(NRANG)
        GO TO 40
   30   CALL SPFIT (DIFF,RLANG,ELM,NRANG)
        CALL SPLVAL (DIFF,NRANG,ELM,0.,RLANS,DUM,IELM)
   40   CONTINUE

        RETURN
        END


C DECK SCTH      -  Computes longcrested/shortcrested time histories
*       8/31/89     11:10 am

        SUBROUTINE SCTH

*        Compute shortcrested/longcrested time histories for
*                wave height and the 6 DOF motions,
*             surge, sway, heave, roll, pitch, and yaw,
*              at one speed, one predominant heading,
*   (identified by significant wave height and modal wave period)


        COMMON DUMMY,U$,C$,Iv$,Ivu$,PAGE,EC$,BELL,DISP,
     2 CLR,Y$,N$,N,Samplerate,Dt,Runnumber,Waveheight,Heading,
     2 Trial$,Date$,Time$,Location$,Personnel$,
```

```
     2 NameS,Factor(32),UnitsS,
     2 CommentsS,Count,B,Plimit,Nlimit,Nparam,
     2 Results(32,4),Dindx(32,2),FIS,SMPDATAS,STHDATAS,DATAS,
     2 SHIPTYPS,SHIPS,VARIANTS,CYCLES,LSHIP,LDATAS,LSTHDATA,LSMPDATA
       CHARACTER*80 FIS,SMPDATAS,STHDATAS,DATAS
       CHARACTER*8 SHIPTYPS,SHIPS
       CHARACTER VARIANTS*1,CYCLES*2
       INTEGER Dindx
       COMMON /DTITL/ DtitleS
       CHARACTER*72 DtitleS
       COMMON /BK1/ SCRMS(10),NMAX
       COMMON /BK2/ UNTCONV,VKMETR
       COMMON /SINCOS/ SI(0:3600),CO(0:3600),XJTX,RDX,DRX,X2PI
       COMMON /EMA/ EIC,ESPEED,EHEAD,ESIGWH,ETMODAL,STATIS,
     2 ESTART,EEND,NW,NMU,CHDNG(11),B2(11),WE(150,11),
     2 COEFR(16500),COEFI(16500)
       CHARACTER*4 US,CS,IvS,IvuS,OptionS,AS,UPCS
       CHARACTER YS,NS,ECS,BELL,DISP*8,PAGE*2,CLR*2
       CHARACTER*18 DateS,TimeS,NameS(32),UnitsS(32)
       CHARACTER*40 TrialS,LocationS,PersonnelS,CommentsS
       INTEGER TT,XS,XE,XL
       INTEGER*4 JA
       REAL Min(32),Max(32),Mean
       DOUBLE PRECISION Temp,ARG,Sum(32),Sumsqr(32)
       DIMENSION THSC(10),THLC(10)
       DATA EPS/0.001/

       AS='CLS'

*-----------------------------------------------------------------------
*              Initialize analysis arrays

       DO 10 I=1,N
       Max(I)=(-32767)
       Min(I)=(32767)
       Sum(I)=0
       Sumsqr(I)=0
    10 CONTINUE

*-----------------------------------------------------------------------
*          Define variables for start and end times

       TSTART=ESTART
       TEND=EEND
       TLRUN=TEND-TSTART
       Xs=TSTART*Samplerate+1
       Xe=TEND*Samplerate+1
       Xl=TLRUN*Samplerate+1
       IF (Xs.LE.0) Xs=1
       Xe=Xs+Xl-1
       TSTART=(Xs-1.)*DT
       TEND=(Xe-1.)*DT
       ESTART=TSTART
       EEND=TEND

*-----------------------------------------------------------------------
*          Open binary data file of time histories

       FIS = STHDATAS(1:LSTHDATA)//'\'//DATAS(1:LDATAS)//'.DAT'
       OPEN (12,FILE=FIS,FORM='UNFORMATTED',STATUS='UNKNOWN')
```

```
      ICOUNT=COUNT            ! no. of samples in run
      WRITE (12) ICOUNT,N

      WRITE ( *,2000) (Names$(I),I=1,7),(Units$(I),I=1,7)
      WRITE (10,2000) (Names$(I),I=1,7),(Units$(I),I=1,7)
 2000 FORMAT (///11X,'FIRST 20 SECONDS OF WAVE HEIGHT AND 6DOF TIME '
     2 'HISTORIES'//5X,'TIME',4X,A8,1X,A8,2X,2A8,2X,2A8,3X,A8/
     2 6X,'SEC',5X,A6,3X,A6,3X,A6,3X,A6,4X,A6,2X,A6,4X,A6/)

      TCLR=30    ! DELTA TIME IN SECONDS WITHIN THE RUN TO CLEAR SCREEN
      ICLR=TCLR*Samplerate+1

*======================================================================
*         Compute time histories as a function of time, heading,
*                 frequency and channel

*----------------------------------------------------------------------
      IT=0
      DO 700 TT=Xs,Xe         !  Loop over time

      TIM = (TT-1.)*DT
      TDIFF=TIM-TSTART
      IT=IT+1
      Count=IT

      DO 20 M=1,N             !  Initialize THSC to zero for current time
      THSC(M) = 0.
   20 CONTINUE

*----------------------------------------------------------------------
      DO 600 IH=1,NMU         !  Loop over component headings for
*                                shortcrested/longcrested seas

      NHB = (IH-1) * NW * NMAX

      DO 30 M=1,N             !  Initialize THLC to zero for current time
      THLC(M)=0.
   30 CONTINUE

*----------------------------------------------------------------------
      DO 500 I=1,NW           !  Loop over frequency

      NWB = (I-1) * NMAX + NHB

*    Compute sine and cosine for current time
      ARG = WE(I,IH)*TIM
      ARG = AMOD(ARG,X2PI)

      JA = ARG * RDX + 0.5
      SP = SI(JA)             !  Obtain sine from lookup table
      CP = CO(JA)             !  Obtain cosine from lookup table

*----------------------------------------------------------------------
      DO 400 M=1,N            !  Loop over channel
      L = M + NWB
```

```
*    Compute component heading time history for channel m
       THLC(M) = THLC(M) + COEFR(L)*CP - COEFI(L)*SP

  400  CONTINUE                 !  End channel loop


  500  CONTINUE                 !  End frequency loop


*    Compute shortcrested time histories
       DO 40 M=1,N              !  Loop over channels
       THSC(M) = THSC(M) + B2(IH)*THLC(M)
   40  CONTINUE


  600  CONTINUE                 !  End loop over component headings


*    Print shortcrested time histories for all channels
       IF (TDIFF .LE. 20.) WRITE ( *,2010) TIM,(THSC(M),M=1,7)
       IF (TDIFF .LE. 20.) WRITE (10,2010) TIM,(THSC(M),M=1,7)
 2010  FORMAT (F9.2,7F9.3)

       IF (IT .EQ. ICLR) CALL SYSTEM (AS)    ! Clear screen

*    Write shortcrested time histories to file
       WRITE (12) (THSC(M),M=1,N)

       DO 50 M=1,N              !  Perform minimum analysis over channel
       Temp = THSC(M)
       Sum(M) = Sum(M) + Temp
       Sumsqr(M) = Sumsqr(M) + Temp*Temp
       IF (Temp .GT. Max(M)) Max(M) = Temp
       IF (Temp .LT. Min(M)) Min(M) = Temp
   50  CONTINUE


  700  CONTINUE                 !  End loop over time


       CLOSE (12)

*    Compute mean and standard deviation and store in results array
       DO 90 M=1,N
       ARG = (Sumsqr(M) - Sum(M)*Sum(M)/Count)
       IF (ARG .GT. 0.) GO TO 80
       WRITE ( *,1010) M,ARG
       WRITE (10,1010) M,ARG
 1010  FORMAT('SQRT OF A NEG. NUMBER.  M=',I3,'   ARG=',F10.3)
       ARG = 0
   80  Stddev = DSQRT(ARG/(Count-1))
       Mean = Sum(M)/Count
       Results(M,1) = Mean
       Results(M,2) = Stddev
       Results(M,3) = Max(M)
       Results(M,4) = Min(M)
   90  CONTINUE

       RETURN
       END
```

```
C DECK SLENTH   -  Returns location of last non-blank character in a string
*       3/31/88    8:45 am

        SUBROUTINE SLENTH (AS,K)

        CHARACTER*(*) AS
        L=LEN(AS)
        K=L+1
        DO 10 M=1,L
        K=K-1
        IF (AS(K:K).NE.CHAR(32)) GO TO 20   ! Test for trailing blanks
   10   CONTINUE
   20   CONTINUE

        RETURN
        END


C DECK SPFIT    -  Cubic non-parametric spline fit for real data
*       3/31/88    8:50 am

        SUBROUTINE SPFIT (X, Y, ELEMS, NPTS)

*          SPFIT CREATED FROM SPLINE                E N HUBBLE      JUNE 19
*       FITS CUBIC NON-PARAMETRIC SPLINE SEGMENTS
*                  TO SET OF REAL DATA POINTS

*       INPUTS
*          X      =  ARRAY OF REAL INDEPENDENT VARIABLES
*          Y      =  ARRAY OF REAL DEPENDENT VARIABLES
*          NPTS   =  NUMBER OF  (X,Y)  DATA POINTS
*       RETURN
*          ELEMS  =  ARRAY OF (NPTS-1) SEGMENTS IN FOLLOWING FORM
*                    ( Y(I), D(I), Y(I+1), D(I+1) )      ,  WHERE
*             D   =  ARRAY OF SECOND DERIVATIVES AT DATA POINTS

*       ARRAYS A,B,C ARE MAINLY SUB DIAG., DIAGONAL, AND SUPER DIAG.
*       D ARRAY IS THE RIGHT HAND SIDE OF MATRIX EQUATION
*       SECOND DERIVATIVES AT NODES ARE PLACED IN D ARRAY AFTER SOLUTION
*       SOLUTION TECHNIQUE IS GAUSSIAN ELIMINATION
*       BOUNDARY CONDITIONS SET BY EXTRAPOLATION OF SECOND DERIVATIVES

       COMMON/IO/ICARD,IPRIN,POTFIL,COFFIL,RAOFIL,RMSFIL,ORGFIL,SPCFIL,
     2 ISCARD,BLKFIL,SCRFIL,SPLFIL,LCOFIL,LRAFIL,SEVFIL
       INTEGER   ICARD,IPRIN,POTFIL,COFFIL,RAOFIL,RMSFIL,ORGFIL,SPCFIL,
     2 ISCARD,BLKFIL,SCRFIL,SPLFIL,LCOFIL,LRAFIL,SEVFIL
        DIMENSION X(NPTS),Y(NPTS),ELEMS(4,NPTS)
       DIMENSION A(100), B(100), C(100), D(100)
       N = NPTS
       NL1 = N - 1
       NL2 = N - 2
       DO 50 I=2,N
          IF (X(I) .GT. X(I-1))  GO TO 50
             WRITE ( *,888) X(I-1),X(I)
             WRITE (10,888) X(I-1),X(I)
             GO TO 88888
50     CONTINUE
       IF (N .LE. 100)  GO TO 100
          WRITE ( *,999)
          WRITE (10,999)
          N = 100
100    CONTINUE
```

```
      IF (N .GT. 2)  GO TO 125
         D(1) = 0.0
         D(2) = 0.0
         GO TO 375
125   CONTINUE
      IF (N .GT. 3)  GO TO 150
         YDD = 2.*((X(3)-X(2))*Y(1)+(X(2)-X(1))*Y(3)-(X(3)-X(1))*Y(2))
     .              /((X(3)-X(2))*(X(2)-X(1))*(X(3)-X(1)))
         D(1) = YDD
         D(2) = YDD
         D(3) = YDD
         GO TO 375
150   CONTINUE
      DO 200 I=1,N
         A(I) = 0.0
         B(I) = 0.0
         C(I) = 0.0
         D(I) = 0.0
200   CONTINUE
*        SET UP MATRICES(A TRIDIAGONAL STRUCTURE)
      A(1) = (X(3)-X(2))/(X(3)-X(1))
      C(1) = 2.0
      B(1) = 1.0 - A(1)
      D(1) = 6.0*((Y(3)-Y(2))/(X(3)-X(2))-(Y(2)-Y(1))/
     1 (X(2)-X(1)))/(X(3)-X(1))
      H = X(3) - X(2)
      DO 250 I=3,NL1
         HP = X(I+1) - X(I)
         C(I) = HP / (H+HP)
         B(I) = 2.0
         A(I) = 1.0 - C(I)
         D(I) = 6.0*((Y(I+1)-Y(I))/HP-(Y(I)-Y(I-1))/H)/(HP+H)
         H = HP
250   CONTINUE
*        SET BOUNDARY CONDITIONS
      C(2) = (X(2)-X(1))/(X(3)-X(2))
      A(2) = 1.0
      B(2) = -1.0-C(2)
      D(2) = 0.0
      C(2) = -A(2)*A(1)/B(1) + C(2)
      C(N) = (X(N)-X(N-1))/(X(N-1)-X(N-2))
      A(N) = -1.0 - C(N)
      B(N) = 1.0
      D(N) = 0.0
*        SOLVE EQUATIONS
      II = 1
      DO 300 I=1,NL2
         I1 = I + 1
         I2 = I + 2
         AUGH = ABS (B(I))
         IF (AUGH .LT. 1.0E-06)  GO TO 275
            CONST = A(I1) / B(I)
            B(I1) = B(I1) - CONST*C(I)
            D(I1) = D(I1) - CONST*D(I)
         IF (I .NE. NL2)  GO TO 300
            A(N) = A(N) - C(N)*C(I) / B(I)
            D(N) = D(N) - C(N)*D(I) / B(I)
            GO TO 300
275      CONTINUE
            II = I + 1
            D(I) = D(I) / C(I)
            D(I1) = D(I1) - B(I1)*D(I)
```

```
            B(I1) = A(I1)
            A(I1) = 0.0
            D(I2) = D(I2) - A(I2)*D(I)
            A(I2) = 0.0
         IF (I .NE. NL2)  GO TO 300
            A(N) = C(N)
300   CONTINUE
      DET = B(NL1)*B(N) - C(NL1)*A(N)
      STORE = D(N)
      D(N) = (B(NL1)*D(N) - D(NL1)*A(N)) / DET
      D(NL1) = (D(NL1)*B(N) - C(NL1)*STORE) / DET
      IP = 0
      DO 350 I=2,NL2
         JI = N - I
         IF (JI .EQ. IP)  GO TO 350
         IF (JI .EQ. II)  GO TO 325
            D(JI) = (D(JI)-C(JI)*D(JI+1))/B(JI)
            GO TO 350
325      CONTINUE
            IP = JI-1
            STORE = D(JI)
            D(JI) = D(IP)
            D(IP) = (STORE - C(IP)*D(JI+1))/B(IP)
350   CONTINUE
      D(1) = (D(1) - A(1)*D(3) - C(1)*D(2)) / B(1)
*        SET UP SPLINE SEGMENTS
375   CONTINUE
      DO 400 I=1,NL1
         I1 = I + 1
          ELEMS(1,I) = Y(I)
          ELEMS(2,I) = D(I)
          ELEMS(3,I) = Y(I1)
          ELEMS(4,I) = D(I1)
400   CONTINUE
99999 CONTINUE
      RETURN
88888 CONTINUE
      STOP
888   FORMAT ('0 SPFIT -- X VALUES NOT ASCENDING', 2E16.8)
999   FORMAT ('0 SPFIT -- NPTS EXCEEDS 100.  ONLY 99 SEGMENTS RETURNED')
      END


C DECK SPLVAL   -  Evaluates a real non-parametric spline
*       3/31/88     8:50 am

       SUBROUTINE SPLVAL (X, NPTS, ELEMS, X0, Y0, S0, IELM)

*          SPLVAL CREATED FROM SPLFIT
*      EVALUATES A REAL NON-PARAMETRIC SPLINE

*      INPUTS
*         X      =  ARRAY OF INDEPENDENT VARIABLES
*         NPTS   =  NUMBER OF VALUES IN X-ARRAY
*         ELEMS  =  SPLINE SEGMENTS GENERATED BY SPFIT
*         X0     =  X-VALUE AT WHICH SPLINE IS TO BE EVALUATED
*      RETURNS
*         Y0     =  F(X0)  =  Y-VALUE EVALUATED AT X0
*         S0     =  SECOND DERIVATIVE EVALUATED AT X0
*         IELM   =  INDEX OF SPLINE SEGMENT CONTAINING X0

      COMMON/IO/ICARD,IPRIN,POTFIL,COFFIL,RAOFIL,RMSFIL,ORGFIL,SPCFIL,
```

```
     2 ISCARD,BLKFIL,SCRFIL,SPLFIL,LCOFIL,LRAFIL,SEVFIL
      INTEGER    ICARD,IPRIN,POTFIL,COFFIL,RAOFIL,RMSFIL,ORGFIL,SPCFIL,
     2 ISCARD,BLKFIL,SCRFIL,SPLFIL,LCOFIL,LRAFIL,SEVFIL
      DIMENSION X(NPTS),ELEMS(4,NPTS)
      N = NPTS
      IF (X0.GE.X(1) .AND. X0.LE.X(N))  GO TO 100
         WRITE ( *,999) X0
         WRITE (10,999) X0
         GO TO 99999
100   CONTINUE
      DO 200 I=2,N
         IF (X0 .GT. X(I))  GO TO 200
            GO TO 300
200   CONTINUE
300   CONTINUE
      I = I - 1
      XX = X(I+1) - X(I)
      X1 = X0 - X(I)
      X2 = X(I+1) - X0
      XX6 = XX * XX / 6.0
      Y1 = ELEMS(1,I)
      Y2 = ELEMS(3,I)
      S1 = ELEMS(2,I)
      S2 = ELEMS(4,I)
      Y0 =  (S1 * X2**3 + S2 * X1**3) / (6.0 * XX)  +
     .       ( (Y1 - S1*XX6) * X2 + (Y2 - S2*XX6) * X1 ) / XX
      S0 = (S1 * X2  +  S2 * X1) / XX
      IELM = I
      RETURN
99999 CONTINUE
      STOP
999   FORMAT ('0 SPLVAL -- EXTRAPOLATION NOT ALLOWED.  X0 =', E16.8)
      END
```

```
C DECK TFNFIT   -  Fits lateral transfer functions for non-linear roll answer
*       3/31/88     8:50 am

      SUBROUTINE TFNFIT (RLANG,NRANG,RLANS,MOTL,JM,IW,CTFN)

      DIMENSION RLANG(8)
      COMPLEX MOTL(3,30,8),CANS(8),CELM(4,8),CTFN,CDUM

      IF (RLANS .GE. RLANG(1)) GO TO 10
      CTFN = MOTL(JM,IW,1)
      GO TO 40
   10 IF (RLANS .LE. RLANG(NRANG)) GO TO 20
      CTFN = MOTL(JM,IW,NRANG)
      GO TO 40

   20 DO 30 IA=1,NRANG        !  Loop over 8 mean roll angles
      CANS(IA) = MOTL(JM,IW,IA)
   30 CONTINUE

      CALL CPFIT (RLANG,CANS,CELM,NRANG)
      CALL CPLVAL  (RLANG,NRANG,CELM,RLANS,CTFN,CDUM,IELM)
   40 CONTINUE

      RETURN
      END
```

```
C DECK TRFN     -  Transfer function subroutine
*       8/31/89    11:10 am

        SUBROUTINE TRFN

        COMMON DUMMY,U$,C$,Iv$,Ivu$,PAGE,EC$,BELL,DISP,
     2 CLR,Y$,N$,N,Samplerate,Dt,Runnumber,Waveheight,Heading,
     2 Trial$,Date$,Time$,Location$,Personnel$,
     2 Name$,Factor(32),Units$,
     2 Comments$,Count,B,Plimit,Nlimit,Nparam,
     2 Results(32,4),Dindx(32,2),FI$,SMPDATA$,STHDATA$,DATA$,
     2 SHIPTYP$,SHIP$,VARIANT$,CYCLE$,LSHIP,LDATA$,LSTHDATA,LSMPDATA
        CHARACTER*80 FI$,SMPDATA$,STHDATA$,DATA$
        CHARACTER*8 SHIPTYP$,SHIP$
        CHARACTER VARIANT$*1,CYCLE$*2
        INTEGER Dindx
        COMMON /DTITL/ Dtitle$
        CHARACTER*72 Dtitle$
        COMMON /BK1/ SCRMS(10),NMAX
        COMMON /BK2/ UNTCONV,VKMETR
        COMMON /EMA/ EIC,ESPEED,EHEAD,ESIGWH,ETMODAL,STATIS,
     2 ESTART,EEND,NWW,NMU,CHDNG(11),B2(11),EWE(150,11),
     2 COEFR(10,150,11),COEFI(10,150,11)
        COMMON /WAVEPNT/ NWPOINT,WPNTXLOC,WPNTYLOC,WPNTZLOC,WPNTNAMES,
     2 WAVEXLOC,WAVEYLOC,WAVEZLOC
        DIMENSION WPNTXLOC(3),WPNTYLOC(3),WPNTZLOC(3),WAVEXLOC(3),
     2 WAVEYLOC(3),WAVEZLOC(3)
        CHARACTER WPNTNAMES(3)*20

        CHARACTER*4 U$,C$,Iv$,Ivu$,Option$,A$,UPC$
        CHARACTER Y$,N$,EC$,BELL,DISP*8,PAGE*2,CLR*2
        CHARACTER*18 Date$,Time$,Name$(32),Units$(32)
        CHARACTER*40 Trial$,Location$,Personnel$,Comments$
        COMMON /BK3/ MOTV,MOTL,HJV,HJL,H7,ORGTF,CTEMP
        COMPLEX MOTV(3,30),MOTL(3,30,8),HJV(3,30),HJL(3,30),H7(30)
        COMPLEX ORGTF(30,11,6),CTEMP
        DIMENSION W(150),TR(150),TI(150),S(150),RK(150),RANDP(150),
     2 RANDW(150),OMG(30),TFR(30),TFI(30),R(30),SWAVE(30)
        DIMENSION RLANG(8)
        CHARACTER*4 TITLE(20)
        REAL LPP,KG,KROLL,LCB
        LOGICAL VRT,LAT,ADDRES
        REAL MU
        CHARACTER FILEC*84,STRING*256
        DATA EPS /0.5/

        PI = 3.1415927
        X2PI = 2*PI
        RD = PI / 180
        RADDEG = 180 / PI
        IC=EIC
        NW=NWW
        SIGWH=ESIGWH
        TMODAL=ETMODAL
        SHPSPD=ESPEED
        HDNG=180-EHEAD          ! Convert SMP output heading reference to
                                ! internal heading reference (180 deg diff)

*-----------------------------------------------------------------------
*       Open file of origin motion transfer functions from SMP
```

```
      FIS = SMPDATAS(1:LSMPDATA)//'\'//
     2 SHIPS(1:LSHIP)//VARIANTS(1:1)//'.ORG'
      OPEN (11,FILE=FIS,FORM='UNFORMATTED',STATUS='OLD')

*                       Read header record
      READ (11) TITLE,NVK,NNMU,NOMEGA,OMG,NRANG,RLANG,VRT,LAT,
     2 ADDRES,LPP,BEAM,DRAFT,DISPLM,GM,DELGM,KG,KROLL,LCB,GRAV,RHO,
     2 VKDES,VKINC,DBLWL

      GRAV = GRAV * UNTCONV
      LPP = LPP * UNTCONV
      LCB = LCB * UNTCONV
      DBLWL = DBLWL * UNTCONV


*                   Compute 150 wave frequencies

      DW = (OMG(NOMEGA)-OMG(1)) / (NW-1)
      WI = OMG(1)
      DO 10 IW=1,NW                    !  Loop over 150 frequencies
      W(IW) = WI + (IW-1)*DW
   10 CONTINUE


*         Compute 2 parameter BRETSCHNEIDER wave spectra
*                  for 150 wave frequencies

      CALL BRWVSP(NW,SIGWH,TMODAL,W,S)
      DO 20 IW=1,NW             !  Compute wave amplitudes
      RK(IW) = SQRT(2*S(IW)*DW)
   20 CONTINUE


*                  Store component headings

      IF (IC .EQ. 1) SHEAD=HDNG+15.          !  Longcrested  seas
      IF (IC .EQ. 2) SHEAD=HDNG+90.          !  Shortcrested seas

      DO 30 IH=1,NMU           !  Loop over component headings
      ARG = SHEAD - IH*15.
      IF (ARG .LT. 0.) ARG = ARG + 360.
      CHDNG(IH) = ARG
   30 CONTINUE


*   Compute weighting constants as a function of component headings

      B2(1)=1.                 !  Longcrested weighting constant
      IF (IC.EQ.1) GO TO 50

*   Shortcrested weighting constants for 11 component headings

      PION12=PI/12
      DO 40 K=1,6
      A=(K-1)*PION12
      CA=COS(A)
      CON=CA*CA/6
      SQCON=SQRT(CON)
      L=K+5
      B2(L)=SQCON
      IF (K.EQ.1) GO TO 40
      L=7-K
```

```
      B2(L)=SQCON
   40 CONTINUE

*    Compute 2 parameter BRETSCHNEIDER wave spectra
*              for 30 wave frequencies
   50 CALL BRWVSP(NOMEGA,SIGWH,TMODAL,OMG,SWAVE)

*    Perform roll iteration for specified seaway
      CALL RLITER (SHPSPD,NMU,B2,CHDNG,STATIS,SWAVE,RADDEG,RLANS)

*    Store origin motion transfer functions
      CALL ORGTFN (SHPSPD,NMU,CHDNG,RLANS,RADDEG)

*---------------------------------------------------------------------
*    Compute standard deviation (RMS) for wave height and
*             6 DOF motions in frequency domain

      DO 80 JC=1,N           !  Loop over channel
      JC1=JC-1
      SCRMS(JC)=0

      DO 70 IH=1,NMU         !  Loop over component headings
      DO 60 IW=1,NOMEGA      !  Loop over wave frequency

      IF (JC.EQ.1) THEN
        TFAMP=1                            !  Wave height at Origin
      ELSEIF (JC.GE.2 .AND. JC.LE.7) THEN
        TFAMP=CABS(ORGTF(IW,IH,JC1))       !  6 DOF motions
      ELSE
        TFAMP=1                            !  Wave height at a point
      ENDIF

      R(IW)=TFAMP**2 * SWAVE(IW) * B2(IH)**2
   60 CONTINUE               !  End loop over frequency

*    Compute variance values of wave height and 6DOF motions
*                for component headings
      CALL ALGRNG(NOMEGA,OMG,R,AREA)
      SCRMS(JC)=SCRMS(JC)+AREA

   70 CONTINUE               !  End loop over headings

*    Compute standard deviation (RMS) values for
*            wave height and 6DOF motions
      SCRMS(JC)=SQRT(ABS(SCRMS(JC)))

   80 CONTINUE               !  End loop over channel

      DO 200 IH=1,NMU        !  Loop over component headings

      ARG=CHDNG(IH)
      IPLANE=1
      IF (ARG.LT.0. .OR. ARG.GT.180.) IPLANE=2
      NARG = (ARG/15 + 1)
      IF (IPLANE .EQ. 2) ARG = ABS(ARG - 360.)
      MU = ABS(ARG) * RD     ! Component heading angle in radians
      COSMU = COS(MU)
```

```
      SINMU = SIN(MU)

*-----------------------------------------------------------------
*               Get random numbers as a function of
*         ,         heading, phase and frequency


*    Select seed for random number generator for each heading
      SEED = NARG + 2000
      X=RANDS(SEED)


*    Save random numbers for phase angles
      DO 100 IW=1,NW          !  Loop over 150 frequencies
      RANDP(IW) = RND()
  100 CONTINUE


*------------------------------------------------------------------
*   Determine if it is necessary to adjust frequencies randomly
*        ( beam seas or ship speed = zero knots )

      NFLAG = 0               !  Don't adjust frequencies randomly
      IF (ARG.EQ.90. .OR. ARG.EQ.270.
    2 .OR. ARG.EQ.-90. .OR. SHPSPD.EQ.0.)
    2 NFLAG = 1               !  Adjust frequencies randomly


      IF (NFLAG.EQ.0) GO TO 130

*    Select seed for random number generator for frequencies
      SEED = NARG + 3000
      X=RANDS(SEED)

*    Save random numbers for frequencies
      DO 120 IW=1,NW          !  Loop over 150 frequencies
      RANDW(IW) = RND()
  120 CONTINUE

  130 CONTINUE



*------------------------------------------------------------------
*    Compute 150 encounter frequencies

      AL = VKMETR * SHPSPD * COSMU / GRAV
      DO 140 IW=1,NW          !  Loop over 150 frequencies

      EWE(IW,IH) = ABS(W(IW)*(1.-AL*W(IW)))

*    Encounter frequencies below 0.05 rad/sec are not allowed
      IF (EWE(IW,IH) .LT. 0.05) EWE(IW,IH) = 0.05

      IF (NFLAG .EQ. 0) GO TO 140

*    Adjust frequencies randomly  (beam seas and/or zero ship speed)

      DELTA = 0.99*DW/2.
      WEC = EWE(IW,IH)
      WEL = WEC - DELTA
      RAND = RANDW(IW)
```

```
      EWE(IW,IH) = WEL + RAND*2.*DELTA

  140 CONTINUE                 ! End loop over frequency


*-----------------------------------------------------------------
*    Interpolate transfer functions for 150 frequencies

      DO 170 JC=1,N            ! Loop over channel
      JC1 = JC - 1
      JC7 = JC - 7

      DO 150 IW=1,NOMEGA       ! Loop over 30 wave frequencies

      IF (JC .EQ. 1) THEN
*    Wave height transfer function at Origin location
      TFR(IW) = 1                         ! Transfer function real part
      TFI(IW) = 0                         ! Transfer function imaginary part

      ELSEIF (JC.GE.2 .AND. JC.LE.7) THEN
*    6 DOF motion transfer functions at Origin location
      TFR(IW) = REAL(ORGTF(IW,IH,JC1))    ! Transfer function real part
      TFI(IW) = AIMAG(ORGTF(IW,IH,JC1))   ! Transfer function imaginary part

      ELSE
*    Wave height transfer function at other point locations
      XK = OMG(IW)**2 / GRAV              ! Compute wave number, K
      TFAMPL = 1                          ! Transfer function amplitude
      XBAR = WAVEXLOC(JC7)                ! X location referenced to LCG
      YBAR = WAVEYLOC(JC7)                ! Y location referenced to LCG
      PHS = - XK * (XBAR*COSMU + YBAR*SINMU)
      TFPHS = PHS                         ! Transfer function phase in
radians
      TFR(IW) = TFAMPL * COS(TFPHS)       ! Transfer function real part
      TFI(IW) = TFAMPL * SIN(TFPHS)       ! Transfer function imaginary part

      ENDIF

  150 CONTINUE                 ! End loop over 30 frequencies

      CALL INTRPL (NOMEGA,OMG,TFR,NW,W,TR)
      CALL INTRPL (NOMEGA,OMG,TFI,NW,W,TI)

      DO 160 IW=1,NW           ! Loop over 150 wave frequencies
      ARG1 = TR(IW)
      ARG2 = TI(IW)
      AMP = SQRT(ARG1*ARG1 + ARG2*ARG2)
      PHS = ATAN2D(ARG2,ARG1,RADDEG)
      COEFR(JC,IW,IH) = AMP
      COEFI(JC,IW,IH) = PHS
  160 CONTINUE                 ! End loop over 150 frequencies

  170 CONTINUE                 ! End loop over channel


*-----------------------------------------------------------------
*    Scale transfer functions by wave spectral amplitudes

      DO 180 IW=1,NW           ! Loop over 150 frequencies
      DO 180 JC=1,N            ! Loop over channel
      COEFR(JC,IW,IH)=RK(IW)*COEFR(JC,IW,IH)
```

```
  180   CONTINUE                ! End loops over channel and frequency

*-----------------------------------------------------------------------
*    Add transfer function phase angles and save final transfer
*           functions in real and imaginary form

        DO 190 IW=1,NW          ! Loop over 150 frequencies
        RPH = X2PI*RANDP(IW)
        DO 190 JC=1,N           ! Loop over channel
        AMP = COEFR(JC,IW,IH)
        PHS = RPH + COEFI(JC,IW,IH)*RD
        COEFR(JC,IW,IH) = AMP*COS(PHS)
        COEFI(JC,IW,IH) = AMP*SIN(PHS)
  190   CONTINUE                ! End loops over channel and frequency


  200   CONTINUE                ! End loop over component headings

        CLOSE (11)

        RETURN
        END


C DECK UCASE    -  Converts strings to uppercase
*       4/16/88    11:20 pm

        SUBROUTINE UCASE (AS,L)

        CHARACTER*(*) AS
        CHARACTER*1 LC(26),UC(26)
        DATA LC /'a','b','c','d','e','f','g','h','i','j','k','l','m',
     2 'n','o','p','q','r','s','t','u','v','w','x','y','z'/
        DATA UC /'A','B','C','D','E','F','G','H','I','J','K','L','M',
     2 'N','O','P','Q','R','S','T','U','V','W','X','Y','Z'/

        DO 20 I=1,L
        DO 10 J=1,26
        IF (AS(I:I) .NE. LC(J)) GO TO 10
        AS(I:I) = UC(J)
        GO TO 20
10      CONTINUE
20      CONTINUE

        RETURN
        END


C PROGRAM END

***********************************************************************
```

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APPENDIX B
LISTING OF ACTH PROGRAM

```
C DECK ACTH          -  ACCESS program for STH time histories, ACTH
*     9/3/89      9:00 pm

      PROGRAM ACTH

*
*                -----------------------------------
*               |        ACTH  -  Main Program      |
*                -----------------------------------

C SUBLIST

*    ----------------------------------------------------------------------
*   |                       List of subroutines                            |
*   |                  -------------------------                           |
*   |  no.   name          type                 description                |
*   |----------------------------------------------------------------------|
*   |                                                                      |
*   |   1   ACTHRESP    subroutine     ACTH ship responses                 |
*   |   2   ATAN2D      function       Arctangent function in degrees for  |
*   |   3   CHKPNT      subroutine     Checks STH point locations against  |
*   |                                  ACTH point locations                |
*   |   4   FLENTH      subroutine     Finds location of first non-blank   |
*   |                                  character in a string               |
*   |   5   RDACTHINP   subroutine     Reads ACTH input file               |
*   |                                                                      |
*   |----------------------------------------------------------------------|
*   |                                                                      |
*   |   6   RDSTHTEXT   subroutine     Reads STH text file                 |
*   |   7   SLENTH      subroutine     Returns location of last non-blank  |
*   |                                  character in a string               |
*   |   8   UCASE       subroutine     Converts strings to uppercase       |
*   |   9   WRACTHLOG   subroutine     Write ACTHLOG text file             |
*   |  10   WRACTHTEXT  subroutine     Write ACTH text file                |
*   |                                                                      |
*    ----------------------------------------------------------------------


*---------------------------------------------------------------------------
*                                  SHIP RESPONSE
*   POINT     SYSTEM          NO           NAME
*--------------------------------------------------------------------------

*     0        EARTH         1-6  -  Origin Motions (Surge, Sway, Heave,
*                                                 Roll, Pitch, Yaw)
*                              7  -  Wave height at the Origin location

*    >0        EARTH         1-3  -  Motions at a point (Longitudinal,
*                                                   Lateral, Vertical)
*                              4  -  Relative motion at a point
*                              7  -  Wave height at a point

*    >0        SHIP          1-3  -  Forces at a point  (Longitudinal,
*                                                   Lateral, Vertical)

*    Ship response velocities and accelerations are obtained by
*    selecting the TYPE variable = 2 (vel.), = 3 (acc.).  Note
```

```
*    TYPE = 1 (displ.)
*------------------------------------------------------------------------

*                   Equations for Motions at a Point
*------------------------------------------------------------------------

*           ELONG = surge - ybar*sin(yaw) + zbar*sin(pitch)
*                   + xbar*[cos(yaw)+cos(pitch)-2]
*           ELATE = sway  - zbar*sin(roll) + xbar*sin(yaw)
*                   + ybar*[cos(roll)+cos(yaw)-2]
*           EVERT = heave - xbar*sin(pitch) + ybar*sin(roll)
*                   + zbar*[cos(pitch)+cos(roll)-2]


*  The Forces in the Ship system in the X, Y, and Z directions are

*           SLONG = (-surgacc) * [cos(yaw)*cos(pitch)]

*              + (-swayacc) * [sin(yaw)*cos(pitch)]

*                 + [(-heavacc) - 1] * [-sin(pitch)]

*  SLATE = (-surgacc) * [cos(yaw)*sin(pitch)*sin(roll) - sin(yaw)*cos(roll)]

*       + (-swayacc) * [cos(yaw)*cos(roll) + sin(yaw)*sin(pitch)*sin(roll)]

*          + [(-heavacc) - 1] * [cos(pitch)*sin(roll)]


*  SVERT = (-surgacc) * [sin(yaw)*sin(roll) + cos(yaw)*sin(pitch)*cos(roll)]

*       + (-swayacc) * [sin(yaw)*sin(pitch)*cos(roll) - cos(yaw)*sin(roll)]

*          + [(-heavacc) - 1] * [cos(pitch)*cos(roll)]

*   where  surgacc, swayacc, and heavacc  are the Earth system translational
*   accelerations in the x, y, and z directions and  '1' is the acceleration
*   of gravity.


C DIMENSIONS

      COMMON /BLK0/ PI,DEGRAD,RADDEG,MONTHS,WAVEHTS,ORGNAMES,
     2 EPTNAMES,SPTNAMES,CHTYPES,CHUNITS,CHSYSTMS
      CHARACTER MONTHS(12)*3,WAVEHTS*12,ORGNAMES(6)*12
      CHARACTER EPTNAMES(7)*12,SPTNAMES(7)*12
      CHARACTER CHTYPES(5)*3,CHUNITS(7)*6,CHSYSTMS(2)*5

      COMMON /BLK1/ AS,FIS,STHDATAS,LSTHDATA,SRUN,KSRUN,LSRUN,
     2 SHIPTYPS,TRIALS,LTRIAL,SHIPS,LSHIP,VARIANTS,CYCLES,SUNITS,
     2 LSUNIT,COMMENTS
      CHARACTER*80 AS,FIS,STHDATAS
      CHARACTER SRUN*6,SHIPTYPS*8,TRIALS*40,SUNITS*6,COMMENTS*40
      CHARACTER SHIPS*5
      CHARACTER VARIANTS*1,CYCLES*2
```

```
      COMMON /BLK2/ STHRUN,CNT,COUNT,NSTHCHAN,GRAV,LPP,LCG,DBLWL,
     2 SRATE,DT,TSTART,TSTOP,TRUN,WAVEHT,SURGE,SWAY,HEAVE,ROLL,PITCH,
     2 YAW,STHDATA,WAVEHTP,SHPSPD,HDNG,SEATYPS,SIGWH,TMODAL,STATIS,
     2 STHCHN,STHUNT,STHSTD,ASCII
      INTEGER CNT,COUNT,ASCII
      REAL LPP,LCG
      CHARACTER STHCHN(10)*8,STHUNT(10)*6,SEATYPS*2
      REAL STHSTD(10,2),STHDATA(10),WAVEHTP(3)

      COMMON /BLK3/ ACTHDATAS,LACTHDATA,STARTRUN,NRUNS,ACTHRUN,DTGS,
     2 ARUN,KARUN,LARUN,NPOINT,PNT,PNTXLOC,PNTYLOC,PNTZLOC,PNTNAMES,
     2 NCHMAX,NCHAN,POINTS,SHIPSYS,CHNPTNO,CHNXLOC,CHNYLOC,CHNZLOC,
     2 CHNPTNA,CTITLE,CTYPE,CUNITS,CSYSTM,CH,CHN,CHNNUM,C1,ACTHDATA,
     2 FACTOR,RESULTS,PEAK
      CHARACTER*80 ACTHDATAS
      CHARACTER ARUN*6,DTGS*13
      INTEGER STARTRUN,ACTHRUN,PNT,POINTS,SHIPSYS
      DIMENSION PNTXLOC(0:10),PNTYLOC(0:10),PNTZLOC(0:10)
      CHARACTER PNTNAMES(0:10)*20
      DIMENSION CHNXLOC(16),CHNYLOC(16),CHNZLOC(16)
      INTEGER CHNPTNO(16)
      CHARACTER*20 CHNPTNA(16)
      CHARACTER*12 CTITLE(16)
      CHARACTER*4 CTYPE(16)
      CHARACTER*4 CUNITS(16)
      CHARACTER*5 CSYSTM(16)
      INTEGER CH(16,5),CHN,CHNNUM
      INTEGER*2 C1(16)
      REAL ACTHDATA(16)
      DIMENSION FACTOR(16),RESULTS(16,4),PEAK(16)

      CHARACTER*8 Date$
      CHARACTER*11 Time$

      COMMON /WAVEPNT/ NWPOINT,WPTNUM,WPNTXLOC,WPNTYLOC,WPNTZLOC,
     2 WPNTNAMES
      DIMENSION WPTNUM(3),WPNTXLOC(3),WPNTYLOC(3),WPNTZLOC(3)
      CHARACTER WPNTNAMES(3)*20
      INTEGER WPTNUM

      COMMON /ACTHWVPT/ NAWPOINT,AWPTNUM,AWPNTXLOC,AWPNTYLOC,
     2 AWPNTZLOC,AWPNTNAMES
      DIMENSION AWPTNUM(3),AWPNTXLOC(3),AWPNTYLOC(3),AWPNTZLOC(3)
      CHARACTER AWPNTNAMES(3)*20
      INTEGER AWPTNUM

      COMMON /BLK4/ EFLAG,ISTHFLAG,CHNFLAG
      INTEGER EFLAG,CHNFLAG(16)

C CONSTANTS

      DEGRAD = PI / 180
      RADDEG = 180 / PI
      NCHMAX = 16                 ! Max no of channels

C START

      FI$ = 'ERROR.TEX'
```

```
      OPEN (8,FILE=FIS,STATUS='UNKNOWN')
      EFLAG = 0                         ! Error flag

*----------------------------------------------------------------------
*                  Read ACTH.INP file

 1000 FORMAT(A)

      FIS = 'ACTH.INP'
      OPEN (1,FILE=FIS,STATUS='OLD')

      READ(1,1000) STHDATAS             ! STH (Origin time history) data path
      READ(1,1000) ACTHDATAS            ! ACTH (Motions at a point) data path
      READ(1,1000) SHIPS

      CALL SLENTH (STHDATAS,LSTHDATA)
      CALL SLENTH (ACTHDATAS,LACTHDATA)
      CALL SLENTH (SHIPS,LSHIP)

      CALL RDACTHINP                    ! Read ACTH.INP file

      IF (EFLAG .GT. 0) THEN
        AS='CLS'
        CALL SYSTEM (AS)
        WRITE (*,3000)
        WRITE (8,3000)
        DO 10 CHN=1,NCHAN
        IF (CHNFLAG(CHN) .EQ. 1) THEN
          WRITE (*,3010) CHN,CH(CHN,1),CH(CHN,5)
          WRITE (8,3010) CHN,CH(CHN,1),CH(CHN,5)
        END IF
   10   CONTINUE
        WRITE (*,3020)
        WRITE (8,3020)
        GO TO 300                       ! STOP
      END IF

 3000 FORMAT (///22X,'ERROR  -  ACTH program stopped.'///22X,
     2 'CHANNEL    RESPONSE    POINT')
 3010 FORMAT (23X,I3,9X,I3,8X,I3)
 3020 FORMAT (//8X,'does not have a corresponding wave point number '
     2 'in ACTH.INP'////)


      READ (1,1000) AS
      READ (1,'(15X,I5)') STARTRUN
      READ (1,'(16X,I5)') NRUNS
      READ (1,1000) AS
      READ (1,1000) AS


*----------------------------------------------------------------------

      ACTHRUN = STARTRUN - 1


      ISTHFLAG = 0                      ! Count of STH runs skipped due to error

      DO 200 JRN = 1,NRUNS              ! Loop over runs

      EFLAG = 0                         ! Error flag
```

```
      A$='CLS'
      CALL SYSTEM (A$)

      WRITE (*,'(//22X,"Access Time History Program (ACTH) ")')
      WRITE (*,'(///,27X,"Total number of runs =",I3)') NRUNS
      WRITE (*,'(/,27X,"Start run number =",I3)') STARTRUN

      ACTHRUN = ACTHRUN + 1
      WRITE (*,'(///,27X,"Working on run number",I3)') ACTHRUN

      WRITE (ARUN,'(I6)') ACTHRUN
      CALL FLENTH (ARUN,KARUN)
      CALL SLENTH (ARUN,LARUN)

      READ (1,*) STHRUN            ! Read STH run number

      WRITE (SRUN,'(I6)') STHRUN
      CALL FLENTH (SRUN,KSRUN)
      CALL SLENTH (SRUN,LSRUN)


*-----------------------------------------------------------
*                 Read STH time history file

      FIS = STHDATA$(1:LSTHDATA)//'\SR'//SRUN(KSRUN:LSRUN)//'.DAT'
      OPEN (2,ERR=20,FILE=FIS,FORM='UNFORMATTED',STATUS='OLD')
      GOTO 30

   20 EFLAG = 1                    ! STH run does not exist
      ISTHFLAG = ISTHFLAG + 1
      GOTO 190

   30 READ (2) COUNT,NSTHCHAN
      TRUN = (COUNT-1)*DT          ! Run length in seconds


*-----------------------------------------------------------
*                 Read STH text file

      CALL RDSTHTEXT


*-----------------------------------------------------------------
*     Compare wave point locations in ACTH.INP and SRN.TEX

      IF (NAWPOINT .GT. 0) CALL CHKPNT
      IF (EFLAG .GT. 0)  GOTO 190


*-----------------------------------------------------------------
*                 Get DATE and TIME

      CALL DATE(Date$)
      CALL TIME(Time$)
      READ (Date$,"(I2)") MONTH
      DTG$ = Date$(4:5)//Time$(1:2)//Time$(4:5)//'L '//MONTHS(MONTH)//
     2 Date$(7:8)


*-----------------------------------------------------------
*                 Open ACTH time history file
```

```
      IF (ASCII .EQ. 1) THEN
        FIS = ACTHDATA$(1:LACTHDATA)//'\AR'//ARUN(KARUN:LARUN)//'.DAT'
        OPEN (3,FILE=FIS,FORM='UNFORMATTED',STATUS='UNKNOWN')
        WRITE (3) COUNT,NCHAN

      ELSE
        FIS = ACTHDATA$(1:LACTHDATA)//'\AR'//ARUN(KARUN:LARUN)//'.ASC'
        OPEN (3,FILE=FIS,STATUS='UNKNOWN')
        WRITE (3,'(2I5)') COUNT,NCHAN

      ENDIF

*---------------------------------------------------------------------

      DO 100 CNT = 1,COUNT           ! Start loop over time (samples)

*    Read STH data for one point in time

      READ (2) (STHDATA(I),I=1,NSTHCHAN)

      WAVEHT = STHDATA(1)           !  Wave height at Origin
      SURGE  = STHDATA(2)
      SWAY   = STHDATA(3)
      HEAVE  = STHDATA(4)
      ROLL   = STHDATA(5)
      PITCH  = STHDATA(6)
      YAW    = STHDATA(7)
      IF (NSTHCHAN .GT. 7) THEN
        DO 40 I=8,NSTHCHAN
        M = I - 7
        WAVEHTP(M) = STHDATA(I)      !  Wave height at a point
   40   CONTINUE
      END IF

      CALL ACTHRESP                  ! Compute ACTH ship responses

      IF (ASCII .EQ. 1) THEN         ! Binary output data format
        WRITE (3) (ACTHDATA(I),I=1,NCHAN)

      ELSE                           ! ASCII output data format
        KL = 0
        IF (NCHAN .LE. 8) THEN
          KL = KL + 1
          WRITE (3,2000) CNT,KL,(ACTHDATA(I),I=1,NCHAN)
 2000     FORMAT (2I5,8F8.3)

        ELSE
          KL = KL + 1
          WRITE (3,2000) CNT,KL,(ACTHDATA(I),I=1,8)
          KL = KL + 1
          WRITE (3,2010) KL,(ACTHDATA(I),I=9,NCHAN)
 2010     FORMAT (5X,I5,8F8.3)

        ENDIF

      ENDIF

  100 CONTINUE                       ! End loop over time

      CLOSE (2)                      ! Close STH.DAT file
```

```
      CLOSE (3)                       ! Close ACTH time history file

*                   Write ACTH text file
      CALL WRACTHTEXT

*                   Write ACTHLOG text file
      CALL WRACTHLOG (FIS,ACTHDATAS,LACTHDATA,TRIALS,LTRIAL,
     2 ACTHRUN,TRUN,DTGS,COMMENTS,ASCII)

  190 CONTINUE

      IF (EFLAG .GT. 0) THEN

        IF (ISTHFLAG .EQ. 1) THEN
          WRITE (8,3030)
 3030     FORMAT (///20X,'ERROR  -  Some STH runs not analysed'/)
        END IF

        IF (EFLAG .EQ. 1) THEN
          WRITE(8,3040) STHRUN

        ELSEIF (EFLAG .EQ. 2) THEN
          WRITE(8,3050) STHRUN

        ELSEIF (EFLAG .EQ. 3) THEN
          WRITE(8,3060) STHRUN

        ENDIF

      ENDIF

 3040 FORMAT(/6X,'STH run ',I3,'  does not exist')
 3050 FORMAT(/6X,'STH run ',I3,'  skipped because there are no '
     2 'wave points in the STH run')
 3060 FORMAT(/6X,'STH run ',I3,'  skipped because the STH wave '
     2 'points do not match'/19X,'the ACTH wave points')

  200 CONTINUE                        ! End of loop over runs

      CLOSE (1)                       ! Close ACTH.INP file

      AS='CLS'
      CALL SYSTEM (AS)

      IF (ISTHFLAG .GT. 0) THEN
        WRITE (*,3030)

        IF (ISTHFLAG .EQ. 1) THEN
          WRITE(*,3080)
        ELSE
          WRITE(*,3090) ISTHFLAG
        END IF

        WRITE(*,3100)

      ELSE                            ! No errors found
        WRITE(*,3070)
        WRITE(8,3070)
```

```
      ENDIF

 3070 FORMAT(/22X,'All STH runs were successfully completed')
 3080 FORMAT(/22X,'There was   1  STH run skipped')
 3090 FORMAT(/22X,'There were ',I3,'  STH runs skipped')
 3100 FORMAT(/19X,'Print the  ERROR.TEX  file for details'////)

C QUIT

  300 CLOSE (8)                        ! Close ERROR.TEX file

      STOP
      END


C DECK BLOCK DATA  -  Block data
*     8/14/89    1:50 pm

      BLOCK DATA

      COMMON /BLK0/ PI,DEGRAD,RADDEG,MONTHS,WAVEHTS,ORGNAMES,
     2 EPTNAMES,SPTNAMES,CHTYPES,CHUNITS,CHSYSTMS
      CHARACTER MONTHS(12)*3,WAVEHTS*12,ORGNAMES(6)*12
      CHARACTER EPTNAMES(7)*12,SPTNAMES(7)*12
      CHARACTER CHTYPES(5)*3,CHUNITS(7)*6,CHSYSTMS(2)*5

      DATA PI /3.1415927/
      DATA MONTHS /'JAN','FEB','MAR','APR','MAY','JUN','JUL','AUG',
     2 'SEP','OCT','NOV','DEC'/
      DATA WAVEHTS /'WAVEHT'/
      DATA ORGNAMES /'SURGE','SWAY','HEAVE','ROLL','PITCH','YAW'/
      DATA EPTNAMES /'LONG','LATE','VERT','RELMOT','WVHTP1','WVHTP2',
     2 'WVHTP3'/
      DATA SPTNAMES /'SLONG','SLATE','SVERT','    ','    ','       ',
     2 '     '/
      DATA CHTYPES /'DSP','VEL','ACC','ANG','   '/
      DATA CHUNITS /'FEET','FPS','G-S','DEG','DPS','DPS2','    '/
      DATA CHSYSTMS /'EARTH','SHIP'/

      END


C SUBROUTINES

**********************************************************************


C DECK ACTHRESP    -  ACTH ship responses
*     9/3/89     8:40 pm

      SUBROUTINE ACTHRESP

      COMMON /BLK0/ PI,DEGRAD,RADDEG,MONTHS,WAVEHTS,ORGNAMES,
     2 EPTNAMES,SPTNAMES,CHTYPES,CHUNITS,CHSYSTMS
      CHARACTER MONTHS(12)*3,WAVEHTS*12,ORGNAMES(6)*12
      CHARACTER EPTNAMES(7)*12,SPTNAMES(7)*12
      CHARACTER CHTYPES(5)*3,CHUNITS(7)*6,CHSYSTMS(2)*5

      COMMON /BLK1/ AS,FIS,STHDATAS,LSTHDATA,SRUN,KSRUN,LSRUN,
     2 SHIPTYPS,TRIALS,LTRIAL,SHIPS,LSHIP,VARIANTS,CYCLES,SUNITS,
     2 LSUNIT,COMMENTS
```

```
      CHARACTER*80 AS,FIS,STHDATAS
      CHARACTER SRUN*6,SHIPTYPS*8,TRIALS*40,SUNITS*6,COMMENTS*40
      CHARACTER SHIPS*5
      CHARACTER VARIANTS*1,CYCLES*2

      COMMON /BLK2/ STHRUN,CNT,COUNT,NSTHCHAN,GRAV,LPP,LCG,DBLWL,
     2 SRATE,DT,TSTART,TSTOP,TRUN,WAVEHT,SURGE,SWAY,HEAVE,ROLL,PITCH,
     2 YAW,STHDATA,WAVEHTP,SHPSPD,HDNG,SEATYPS,SIGWH,TMODAL,STATIS,
     2 STHCHN,STHUNT,STHSTD,ASCII
      INTEGER CNT,COUNT,ASCII
      REAL LPP,LCG
      CHARACTER STHCHN(10)*8,STHUNT(10)*6,SEATYPS*2
      REAL STHSTD(10,2),STHDATA(10),WAVEHTP(3)

      COMMON /BLK3/ ACTHDATAS,LACTHDATA,STARTRUN,NRUNS,ACTHRUN,DTGS,
     2 ARUN,KARUN,LARUN,NPOINT,PNT,PNTXLOC,PNTYLOC,PNTZLOC,PNTNAMES,
     2 NCHMAX,NCHAN,POINTS,SHIPSYS,CHNPTNO,CHNXLOC,CHNYLOC,CHNZLOC,
     2 CHNPTNA,CTITLE,CTYPE,CUNITS,CSYSTM,CH,CHN,CHNNUM,C1,ACTHDATA,
     2 FACTOR,RESULTS,PEAK
      CHARACTER*80 ACTHDATAS
      CHARACTER ARUN*6,DTGS*13
      INTEGER STARTRUN,ACTHRUN,PNT,POINTS,SHIPSYS
      DIMENSION PNTXLOC(0:10),PNTYLOC(0:10),PNTZLOC(0:10)
      CHARACTER PNTNAMES(0:10)*20
      DIMENSION CHNXLOC(16),CHNYLOC(16),CHNZLOC(16)
      INTEGER CHNPTNO(16)
      CHARACTER*20 CHNPTNA(16)
      CHARACTER*12 CTITLE(16)
      CHARACTER*4 CTYPE(16)
      CHARACTER*4 CUNITS(16)
      CHARACTER*5 CSYSTM(16)
      INTEGER CH(16,5),CHN,CHNNUM
      INTEGER*2 C1(16)
      REAL ACTHDATA(16)
      DIMENSION FACTOR(16),RESULTS(16,4),PEAK(16)
      DIMENSION CHNXBAR(16),CHNYBAR(16),CHNZBAR(16)
      REAL PRCHDSP(16),PRLAVEL(16),PRVEDSP(16),PRVEVEL(16)
      REAL PRCHVEL(16),PRLODSP(16),PRLOVEL(16),PRLADSP(16)
      REAL THMIN(16),THMAX(16),MEAN
      DOUBLE PRECISION TMP,ARG,SUM(16),SUMSQR(16)
      REAL LONFOR,LATFOR


      IF (CNT .EQ. 1) THEN
*-----------------------------------------------------------------------
*           Initialize variables at start of run

        DO 10 I=1,NCHAN
        FACTOR(I) = 1
   10   CONTINUE

        FTG = 1 / GRAV

        I = 0                           ! Wave height or Origin responses
        PNTXLOC(I) = LCG / (LPP/20)     ! Longitudinal center of gravity
*                                         (from FP)
        PNTYLOC(I) = 0                  ! Centerline
        PNTZLOC(I) = DBLWL              ! Waterplane (from BL)
        PNTNAMES(I) = 'Origin (LCG, CL, WP)'
   20   CONTINUE

        DO 30 CHN = 1,NCHAN
```

```
      THMAX(CHN)=(-32767)
      THMIN(CHN)=(32767)
      SUM(CHN)=0
      SUMSQR(CHN)=0
      PRCHDSP(CHN) = 0
      PRCHVEL(CHN) = 0
      PRLODSP(CHN) = 0
      PRLOVEL(CHN) = 0
      PRLADSP(CHN) = 0
      PRLAVEL(CHN) = 0
      PRVEDSP(CHN) = 0
      PRVEVEL(CHN) = 0

      PNT = CH(CHN, 5)                    ! Channel point

      IF (PNT .EQ. 0) THEN                ! Origin location
        CHNXLOC(CHN) = PNTXLOC(PNT)       ! Station associated with LCG
        CHNYLOC(CHN) = PNTYLOC(PNT)       ! Centerline
        CHNZLOC(CHN) = PNTZLOC(PNT)       ! Waterplane (from BL)
        CHNPTNA(CHN) = PNTNAMES(PNT)      ! Channel point name

      ELSE

*     X, Y, Z  coordinates in SMP Ship Reference system
*          XLOC in station number,
*          YLOC positive to port from centerline,
*          ZLOC positive up from baseline

        XLOC = CHNXLOC(CHN)
        YLOC = CHNYLOC(CHN)
        ZLOC = CHNZLOC(CHN)

*     X, Y, Z  coordinates in right-handed coordinate system
*         XBAR is distance positive forward from
*              longitudinal center of gravity,
*         YBAR is distance positive to port from centerline,
*         ZBAR is distance positive up from waterline

        CHNXBAR(CHN) = LCG - XLOC * (LPP / 20)
        CHNYBAR(CHN) = YLOC
        CHNZBAR(CHN) = ZLOC - DBLWL

      END IF

   30 CONTINUE

    END IF


*-----------------------------------------------------------------------
*               Compute ACTH ship response time histories


    IF (POINTS .EQ. 1) THEN
*----------------------------------------------------------------------
*               Motions at a Point calculations to be done

      ROLRAD = ROLL * DEGRAD
      SR = SIN(ROLRAD)
      CR = COS(ROLRAD)
```

```
        PITRAD = PITCH * DEGRAD
        SP = SIN(PITRAD)
        CP = COS(PITRAD)

        YAWRAD = YAW * DEGRAD
        SY = SIN(YAWRAD)
        CY = COS(YAWRAD)

      END IF


*-----------------------------------------------------------------------

      DO 100 CHN = 1,NCHAN          ! Loop over channel

      IRSP = CH(CHN, 1)             ! Channel response
      ITYP = CH(CHN, 2)             !    "    type
      ISYS = CH(CHN, 4)             !    "    system
      IPNT = CH(CHN, 5)             !    "    point

      IF (ISYS .EQ. 2) THEN         ! Ship system
        ISLONG = 1                  ! Compute longitudinal force
        IF (IRSP.EQ.2 .OR. IRSP.EQ.3) ISLONG = 0
        ISLATE = 1                  ! Compute lateral force
        IF (IRSP.EQ.1 .OR. IRSP.EQ.3) ISLATE = 0
        ISVERT = 1                  ! Compute vertical force
        IF (IRSP.EQ.1 .OR. IRSP.EQ.2) ISVERT = 0
      END IF

      IF (IPNT .EQ. 0) THEN         ! Origin location
*-----------------------------------------------------------------------

        IF (IRSP.GE.1 .AND. IRSP.LE.6) THEN
*-----------------------------------------------------------------------
*               Origin responses

          IF (IRSP .EQ. 1) TEMP = SURGE
          IF (IRSP .EQ. 2) TEMP = SWAY
          IF (IRSP .EQ. 3) TEMP = HEAVE
          IF (IRSP .EQ. 4) TEMP = ROLL
          IF (IRSP .EQ. 5) TEMP = PITCH
          IF (IRSP .EQ. 6) TEMP = YAW
          IF (ITYP .EQ. 1) GOTO 90      ! Displacement or angle
          GOTO 80                       ! Velocity or acceleration
        END IF

        IF (IRSP.EQ.7 ) THEN
*-----------------------------------------------------------------------
*               Wave height at Origin

          TEMP = WAVEHT
          IF (ITYP .EQ. 1) GOTO 90      ! Displacement or angle
          GOTO 80                       ! Velocity or acceleration
        END IF
```

```
      ELSE                            ! Point location
*-------------------------------------------------------------------

        XBAR = CHNXBAR(CHN)
        YBAR = CHNYBAR(CHN)
        ZBAR = CHNZBAR(CHN)

        IF (ISYS .EQ. 1) THEN       ! EARTH system
*-------------------------------------------------------------------

          IF (IRSP.GE.1 .AND. IRSP.LE.3) THEN
*-------------------------------------------------------------------
*                Absolute responses at a point

            IF (IRSP .EQ. 1) THEN          ! Longitudinal
              TEMP = SURGE - YBAR*SY + ZBAR*SP + XBAR*(CY+CP-2)

            ELSEIF (IRSP .EQ. 2) THEN      ! Lateral
              TEMP = SWAY  - ZBAR*SR + XBAR*SY + YBAR*(CR+CY-2)

            ELSE                           ! Vertical
              TEMP = HEAVE - XBAR*SP + YBAR*SR + ZBAR*(CP+CR-2)

            END IF
            IF (ITYP .EQ. 1) GOTO 90       ! Displacement
            GOTO 80                        ! Velocity or acceleration
          END IF

          IF (IRSP .EQ. 4) THEN
*-------------------------------------------------------------------
*                Relative motion at a point

            VERDSP = HEAVE - XBAR*SP + YBAR*SR + ZBAR*(CP+CR-2)
            TEMP = VERDSP - WAVEHTP(IPNT)
            IF (ITYP .EQ. 1) GOTO 90       ! Displacement
            GOTO 80                        ! Velocity or acceleration
          END IF

          IF (IRSP .EQ. 7) THEN
*-------------------------------------------------------------------
*                Wave height at a point

            TEMP = WAVEHTP(IPNT)
            IF (ITYP .EQ. 1) GOTO 90       ! Displacement
            GOTO 80                        ! Velocity or acceleration
          END IF


        ELSE                          ! Ship system

*-------------------------------------------------------------------
*                Compute motions at a point  -  EARTH system

            ELONG = SURGE - YBAR*SY + ZBAR*SP + XBAR*(CY+CP-2)
            ELATE = SWAY  - ZBAR*SR + XBAR*SY + YBAR*(CR+CY-2)
            EVERT = HEAVE - XBAR*SP + YBAR*SR + ZBAR*(CP+CR-2)
```

```
*-----------------------------------------------------------------
*             Next compute velocities at a point

          IF (CNT .EQ. 1) THEN        ! Initial values of displacement
            PRLODSP(CHN) = ELONG
            PRLADSP(CHN) = ELATE
            PRVEDSP(CHN) = EVERT
          END IF

          ELONVEL = (ELONG - PRLODSP(CHN)) * SRATE
          ELATVEL = (ELATE - PRLADSP(CHN)) * SRATE
          EVERVEL = (EVERT - PRVEDSP(CHN)) * SRATE

          PRLODSP(CHN) = ELONG
          PRLADSP(CHN) = ELATE
          PRVEDSP(CHN) = EVERT


*-----------------------------------------------------------------
*             Last compute accelerations at a point

          ELONACC = (ELONVEL - PRLOVEL(CHN)) * SRATE
          ELATACC = (ELATVEL - PRLAVEL(CHN)) * SRATE
          EVERACC = (EVERVEL - PRVEVEL(CHN)) * SRATE

          PRLOVEL(CHN) = ELONVEL
          PRLAVEL(CHN) = ELATVEL
          PRVEVEL(CHN) = EVERVEL


*-----------------------------------------------------------------
*             Convert to Earth System forces in g's
*                including force due to gravity

*                Coordinate system for forces is
*               x pos aft, y pos to stbd, z pos down

          LONFOR = - ELONACC * FTG            ! Longitudinal force
          LATFOR = - ELATACC * FTG            ! Lateral force
          VERFOR = - EVERACC * FTG - 1        ! Vertical force


*-----------------------------------------------------------------
*           Compute Longitudinal, Lateral, and Vertical Forces
*             (including Gravity) in the Ship System using
*                        angle rotation order
*                          yaw, pitch, roll


            IF (ISLONG .EQ. 1) THEN
              SLONG = LONFOR * CY * CP +
     2                LATFOR * SY * CP -
     2                VERFOR * SP
            END IF

            IF (ISLATE .EQ. 1) THEN
              SLATE = LONFOR * (CY * SP * SR - SY * CR) +
     2                LATFOR * (CY * CR + SY * SP * SR) +
     2                VERFOR * CP * SR

            END IF
```

```
          IF (ISVERT .EQ. 1) THEN
            SVERT = LONFOR * (SY * SR + CY * SP * CR) +
     2              LATFOR * (SY * SP * CR - CY * SR) +
     2              VERFOR * CP * CR
          END IF

        IF (IRSP .EQ. 1) THEN        ! Longitudinal force
          TEMP = SLONG
          GOTO 90
        END IF

        IF (IRSP .EQ. 2) THEN        ! Lateral force
          TEMP = SLATE
          GOTO 90
        END IF

        IF (IRSP .EQ. 3) THEN        ! Vertical force
          TEMP = SVERT
          GOTO 90
        END IF

      END IF                       ! EARTH / Ship system

    END IF                         ! Origin / point location


 80 IF (ITYP.EQ.2 .OR. ITYP.EQ.3) THEN     ! Velocity or acceleration
*-----------------------------------------------------------------------
*               Compute velocity

      IF (CNT .EQ. 1) PRCHDSP(CHN) = TEMP
      TEMPVEL = (TEMP - PRCHDSP(CHN)) * SRATE
      IF (CNT .GT. 1) PRCHDSP(CHN) = TEMP

      IF (ITYP .EQ. 2) THEN
        TEMP = TEMPVEL
        GOTO 90
      END IF

*-----------------------------------------------------------------------
*          Compute acceleration

      TEMPACC = (TEMPVEL - PRCHVEL(CHN)) * SRATE
      PRCHVEL(CHN) = TEMPVEL

      IF (.NOT. (IPNT.EQ.0 .AND. (IRSP.GE.4 .AND. IRSP.LE.6))) THEN
        TEMPACC = TEMPACC * FTG
      END IF

      TEMP = TEMPACC

    END IF                         ! Velocity / acceleration type


*-----------------------------------------------------------------------
*          Compute minimum analysis as a function of time
```

```
 90  TMP = TEMP
     SUM(CHN) = SUM(CHN) + TMP
     SUMSQR(CHN) = SUMSQR(CHN) + TMP*TMP
     IF (TEMP .GT. THMAX(CHN)) THMAX(CHN) = TEMP
     IF (TEMP .LT. THMIN(CHN)) THMIN(CHN) = TEMP
     ACTHDATA(CHN) = TEMP

*----------------------------------------------------------------------
 100 CONTINUE                         ! End loop over channels

     IF (CNT .EQ. COUNT) THEN
*----------------------------------------------------------------------
*             Complete minimum analysis for run

       DO 120 CHN = 1,NCHAN
       ARG = (SUMSQR(CHN) - SUM(CHN)*SUM(CHN)/COUNT)
       IF (ARG .GT. 0.) GO TO 110
       ARG = 0
 110   STDDEV = DSQRT(ARG/(COUNT-1))
       MEAN = SUM(CHN)/COUNT
       RESULTS(CHN,1) = MEAN
       RESULTS(CHN,2) = STDDEV
       RESULTS(CHN,3) = THMAX(CHN)
       RESULTS(CHN,4) = THMIN(CHN)
       THMX = RESULTS(CHN,3)
       THMN = RESULTS(CHN,4)
       PEAK(CHN) = THMX
       IF (ABS(THMN) .GT. ABS(THMX)) PEAK(CHN) = THMN
 120   CONTINUE

     END IF

     RETURN
     END

C DECK ATAN2D     - Arctangent function in degrees for any quadrant
*      2/18/89    1:15 pm

     FUNCTION ATAN2D (B,A,RADDEG)

*    Arctangent function to compute angles (in degrees) in any quadrant.
*    The b argument is the imaginary vector.  The A argument is the real
*    vector.

     DATA EPS /1.E-6/
     IF (B .EQ. 0.) ATAN2D =  0.
     IF (B .GT. 0.) ATAN2D = 90.
     IF (B .LT. 0.) ATAN2D =-90.
     IF (ABS(A) .GT. EPS) ATAN2D = ATAN2(B,A) * RADDEG

     RETURN
     END

C DECK CHKPNT     - Checks STH point locations against ACTH point locations
*       3/1/89    2:05 pm

     SUBROUTINE CHKPNT
```

```
      COMMON /WAVEPNT/ NWPOINT,WPTNUM,WPNTXLOC,WPNTYLOC,WPNTZLOC,
     2 WPNTNAMES
      DIMENSION WPTNUM(3),WPNTXLOC(3),WPNTYLOC(3),WPNTZLOC(3)
      CHARACTER WPNTNAMES(3)*20
      INTEGER WPTNUM

      COMMON /ACTHWVPT/ NAWPOINT,AWPTNUM,AWPNTXLOC,AWPNTYLOC,
     2 AWPNTZLOC,AWPNTNAMES
      DIMENSION AWPTNUM(3),AWPNTXLOC(3),AWPNTYLOC(3),AWPNTZLOC(3)
      CHARACTER AWPNTNAMES(3)*20
      INTEGER AWPTNUM

      COMMON /BLK4/ EFLAG,ISTHFLAG,CHNFLAG
      INTEGER EFLAG,CHNFLAG(16)


      IF (NAWPOINT.GT.0 .AND. NWPOINT.EQ.0) THEN
        EFLAG = 2                     ! There are wave points in ACTH.INP but
*                                       no wave points in SRN.TEX file
        ISTHFLAG = ISTHFLAG + 1

      ELSEIF (NAWPOINT .NE. NWPOINT) THEN
        EFLAG = 3                     ! Wave points disagree
        ISTHFLAG = ISTHFLAG + 1

      ELSE
        DO 10 J = 1,NAWPOINT

        IF (AWPTNUM(J).EQ.WPTNUM(J) .AND. AWPNTXLOC(J).EQ.WPNTXLOC(J)
     2     .AND.  AWPNTYLOC(J).EQ.WPNTYLOC(J)) GOTO 10
        EFLAG = 3                     ! Wave points disagree
        ISTHFLAG = ISTHFLAG + 1
        GO TO 20
   10   CONTINUE

      END IF

   20 RETURN
      END


C DECK FLENTH      -  Finds location of first non-blank character in a string
*     11/11/88     6:00 pm

      SUBROUTINE FLENTH (AS,K)

      CHARACTER*(*) AS
      L=LEN(AS)
      K=1
      DO 10 I=1,L
      IF (AS(I:I).EQ.CHAR(32)) GO TO 10
      K=I
      GO TO 20
   10 CONTINUE
   20 CONTINUE

      RETURN
      END


C DECK RDACTHINP   -  Reads ACTH input file
*     8/31/89      1:35 pm
```

```
      SUBROUTINE RDACTHINP

      COMMON /BLK0/ PI,DEGRAD,RADDEG,MONTHS,WAVEHTS,ORGNAMES,
     2 EPTNAMES,SPTNAMES,CHTYPES,CHUNITS,CHSYSTMS
      CHARACTER MONTHS(12)*3,WAVEHTS*12,ORGNAMES(6)*12
      CHARACTER EPTNAMES(7)*12,SPTNAMES(7)*12
      CHARACTER CHTYPES(5)*3,CHUNITS(7)*6,CHSYSTMS(2)*5

      COMMON /BLK1/ AS,FIS,STHDATAS,LSTHDATA,SRUN,KSRUN,LSRUN,
     2 SHIPTYPS,TRIALS,LTRIAL,SHIPS,LSHIP,VARIANTS,CYCLES,SUNITS,
     2 LSUNIT,COMMENTS
      CHARACTER*80 AS,FIS,STHDATAS
      CHARACTER SRUN*6,SHIPTYPS*8,TRIALS*40,SUNITS*6,COMMENTS*40
      CHARACTER SHIPS*5
      CHARACTER VARIANTS*1,CYCLES*2

      COMMON /BLK2/ STHRUN,CNT,COUNT,NSTHCHAN,GRAV,LPP,LCG,DBLWL,
     2 SRATE,DT,TSTART,TSTOP,TRUN,WAVEHT,SURGE,SWAY,HEAVE,ROLL,PITCH,
     2 YAW,STHDATA,WAVEHTP,SHPSPD,HDNG,SEATYPS,SIGWH,TMODAL,STATIS,
     2 STHCHN,STHUNT,STHSTD,ASCII
      INTEGER CNT,COUNT,ASCII
      REAL LPP,LCG
      CHARACTER STHCHN(10)*8,STHUNT(10)*6,SEATYPS*2
      REAL STHSTD(10,2),STHDATA(10),WAVEHTP(3)

      COMMON /BLK3/ ACTHDATAS,LACTHDATA,STARTRUN,NRUNS,ACTHRUN,DTGS,
     2 ARUN,KARUN,LARUN,NPOINT,PNT,PNTXLOC,PNTYLOC,PNTZLOC,PNTNAMES,
     2 NCHMAX,NCHAN,POINTS,SHIPSYS,CHNPTNO,CHNXLOC,CHNYLOC,CHNZLOC,
     2 CHNPTNA,CTITLE,CTYPE,CUNITS,CSYSTM,CH,CHN,CHNNUM,C1,ACTHDATA,
     2 FACTOR,RESULTS,PEAK
      CHARACTER*80 ACTHDATAS
      CHARACTER ARUN*6,DTGS*13
      INTEGER STARTRUN,ACTHRUN,PNT,POINTS,SHIPSYS
      DIMENSION PNTXLOC(0:10),PNTYLOC(0:10),PNTZLOC(0:10)
      CHARACTER PNTNAMES(0:10)*20
      DIMENSION CHNXLOC(16),CHNYLOC(16),CHNZLOC(16)
      INTEGER CHNPTNO(16)
      CHARACTER*20 CHNPTNA(16)
      CHARACTER*12 CTITLE(16)
      CHARACTER*4 CTYPE(16)
      CHARACTER*4 CUNITS(16)
      CHARACTER*5 CSYSTM(16)
      INTEGER CH(16,5),CHN,CHNNUM
      INTEGER*2 C1(16)
      REAL ACTHDATA(16)
      DIMENSION FACTOR(16),RESULTS(16,4),PEAK(16)

      COMMON /ACTHWVPT/ NAWPOINT,AWPTNUM,AWPNTXLOC,AWPNTYLOC,
     2 AWPNTZLOC,AWPNTNAMES
      DIMENSION AWPTNUM(3),AWPNTXLOC(3),AWPNTYLOC(3),AWPNTZLOC(3)
      CHARACTER AWPNTNAMES(3)*20
      INTEGER AWPTNUM

      COMMON /BLK4/ EFLAG,ISTHFLAG,CHNFLAG
      INTEGER EFLAG,CHNFLAG(16)

 1000 FORMAT(A)

*-----------------------------------------------------------------
```

```
*    OUTPUT data format
*          ASCII = 1 (Binary)
*          ASCII = 2 (ASCII)

      READ (1,1000) AS
      READ (1,'(7X,I5)') ASCII
      IF (ASCII.NE.2) ASCII = 1

*-----------------------------------------------------------------
*    Read point locations for wave height at a point

      READ (1,1000) AS
      READ (1,'(18X,I5)') NAWPOINT
      IF (NAWPOINT .GT. 3) NAWPOINT = 3
      READ (1,1000) AS
      READ (1,1000) AS
      READ (1,1000) AS
      IF (NAWPOINT .GT. 0) THEN
        DO 10 PNT=1,NAWPOINT
        READ (1,'(I4,3F8.1,3X,A20)') AWPTNUM(PNT),AWPNTXLOC(PNT),
     2  AWPNTYLOC(PNT),AWPNTZLOC(PNT),AWPNTNAMES(PNT)
   10   CONTINUE
      END IF

*-----------------------------------------------------------------
*    Read point locations

      READ (1,1000) AS
      READ (1,'(13X,I5)') NPOINT
      IF (NPOINT .GT. 10) NPOINT = 10
      READ (1,1000) AS
      READ (1,1000) AS
      READ (1,1000) AS
      IF (NPOINT .GT. 0) THEN
        DO 20 PNT=1,NPOINT
        READ (1,'(I4,3F8.1,3X,A20)') IPNT,PNTXLOC(PNT),
     2  PNTYLOC(PNT),PNTZLOC(PNT),PNTNAMES(PNT)
   20   CONTINUE
      END IF

      READ (1,1000) AS
      READ (1,'(15X,I5)') NCHAN
      IF (NCHAN .GT. NCHMAX) NCHAN = NCHMAX
      READ (1,1000) AS
      READ (1,1000) AS
      READ (1,1000) AS

      POINTS = 0                         ! Point flag is set to off
      SHIPSYS = 0                        ! System flag is set to off (EARTH)

      DO 40 CHN = 1,NCHAN                ! Loop over channel

      READ (1,*) ICHN,IRSP,ITYP,ISYS,IPNT

      ITMP = IPNT
      CHNFLAG(CHN) = 0
      IF (IPNT.GT.0 .AND. ISYS.EQ.1 .AND.
     2            (IRSP.EQ.4 .OR. IRSP.EQ.7)) THEN
        MATCH = 0
        DO 30 I = 1,NAWPOINT
        IF (IPNT .EQ. AWPTNUM(I)) THEN
```

```
          MATCH = 1
          GOTO 30
        ENDIF
   30   CONTINUE
        IF (MATCH .EQ. 0) THEN
          EFLAG = 1                    ! No wave point number for Relative motion
*                                        or wave at a point
          CHNFLAG(CHN) = 1
        END IF
      ENDIF


      IF (IRSP.LE.0 .OR. IRSP.GT.7) IRSP = 1
      IF (ITYP.LE.0 .OR. ITYP.GT.5) ITYP = 1
      IF (ISYS.LE.0 .OR. ISYS.GT.2) ISYS = 1
      IF (IPNT .LT.  0) IPNT = 0

      IF (IPNT .GT. 10) IPNT = 10


      CHNPTNO(CHN) = IPNT              ! Channel point (identified by number)
      CHNXLOC(CHN) = PNTXLOC(IPNT)     !    "      "   x location
      CHNYLOC(CHN) = PNTYLOC(IPNT)     !    "      "   y    "
      CHNZLOC(CHN) = PNTZLOC(IPNT)     !    "      "   z    "
      CHNPTNA(CHN) = PNTNAMES(IPNT)    !    "      "   name


      IF (IPNT .EQ. 0) THEN         ! Origin location

        IF (IRSP.GE.1 .AND. IRSP.LE.6) THEN
*-----------------------------------------------------------------------
*             Origin responses

          CTITLE(CHN) = ORGNAMES(IRSP)
          IF (ITYP .GT. 3) ITYP = 1
          IF (IRSP .LT. 4) THEN
            IUNT = ITYP
          ELSE
            IUNT = ITYP + 3
          END IF
          CUNITS(CHN) = CHUNITS(IUNT)
          IF (IRSP.GT.3 .AND. ITYP.EQ.1) ITYP = 4
          CTYPE(CHN) = CHTYPES(ITYP)
          ISYS = 1                    ! EARTH system
          CSYSTM(CHN) = CHSYSTMS(1)
        END IF


        IF (IRSP .EQ. 7) THEN
*-----------------------------------------------------------------------
*             Wave height at Origin

          CTITLE(CHN) = WAVEHTS
          IF (ITYP.GT.3) ITYP = 1
          CTYPE(CHN) = CHTYPES(ITYP)
          IUNT = ITYP
          CUNITS(CHN) = CHUNITS(IUNT)
          ISYS = 1                    ! EARTH system
          CSYSTM(CHN) = CHSYSTMS(1)
        END IF
```

```
      ELSE                         ! Point location

        IF (ISYS .EQ. 1) THEN      ! EARTH system

          IF (IRSP .GE. 1 .AND. IRSP.LE.3) THEN
*-----------------------------------------------------------------------
*                 Absolute responses at a point

            CTITLE(CHN) = EPTNAMES(IRSP)
            IF (ITYP .GT. 3) ITYP = 1
            CTYPE(CHN) = CHTYPES(ITYP)
            IUNT = ITYP
            CUNITS(CHN) = CHUNITS(IUNT)
            CSYSTM(CHN) = CHSYSTMS(ISYS)
          END IF

          IF (IRSP .EQ. 4) THEN
*-----------------------------------------------------------------------
*                 Relative motion at a point

            IF (IPNT .GT. 3) IPNT = 1
            CTITLE(CHN) = EPTNAMES(IRSP)
            IF (ITYP .GT. 3) ITYP = 1
            CTYPE(CHN) = CHTYPES(ITYP)
            IUNT = ITYP
            CUNITS(CHN) = CHUNITS(IUNT)
            CSYSTM(CHN) = CHSYSTMS(ISYS)
          END IF

          IF (IRSP .EQ. 7) THEN
*-----------------------------------------------------------------------
*                 Wave height at a point

            IF (IPNT .GT. 3) IPNT = 1
            CTITLE(CHN) = EPTNAMES(IPNT+4)
            IF (ITYP.GT.3) ITYP = 1
            CTYPE(CHN) = CHTYPES(ITYP)
            IUNT = ITYP
            CUNITS(CHN) = CHUNITS(IUNT)
            CSYSTM(CHN) = CHSYSTMS(ISYS)
          END IF

          IF (IRSP.EQ.4 .OR. IRSP.EQ.7) THEN
            CHNXLOC(CHN) = AWPNTXLOC(IPNT)    ! Channel wave point x location
            CHNYLOC(CHN) = AWPNTYLOC(IPNT)    !    "     "    "   y    "
            CHNZLOC(CHN) = AWPNTZLOC(IPNT)    !    "     "    "   z    "
            CHNPTNA(CHN) = AWPNTNAMES(IPNT)   !    "     "    "   name
          ENDIF

        ELSE                       ! SHIP system
*-----------------------------------------------------------------------

          IF (IRSP.GE.1 .AND. IRSP.LE.3) THEN
*-----------------------------------------------------------------------
```

```
*              Force responses at a point

          CTITLE(CHN) = SPTNAMES(IRSP)
          ITYP = 3
          CTYPE(CHN) = CHTYPES(ITYP)
          IUNT = 3
          CUNITS(CHN) = CHUNITS(IUNT)
          CSYSTM(CHN) = CHSYSTMS(ISYS)
        END IF

      END IF                    ! EARTH / SHIP system

    END IF                      ! Origin / Point location

    IF (EFLAG .GT. 0) IPNT = ITMP

*------------------------------------------------------------------------
    CTITLE(CHN) = CTITLE(CHN)(1:6)//'  '//CTYPE(CHN)(1:3)

    CH(CHN,1) = IRSP            ! Channel response (identified by number)
    CH(CHN,2) = ITYP            !    "    type          "
    CH(CHN,3) = IUNT            !    "    unit          "
    CH(CHN,4) = ISYS            !    "    system        "
    CH(CHN,5) = IPNT            !    "    point         "

    IF (IPNT .GT. 0) POINTS = 1     ! Point flag is set to on
    IF (ISYS .EQ. 2) SHIPSYS=1      ! System flag is set to on (SHIP)

 40 CONTINUE                    ! End loop over channel

    RETURN
    END


C DECK RDSTHTEXT   -  Reads STH text file
*     8/31/89      1:35 pm

      SUBROUTINE RDSTHTEXT

      COMMON /BLK1/ AS,FIS,STHDATAS,LSTHDATA,SRUN,KSRUN,LSRUN,
     2 SHIPTYPS,TRIALS,LTRIAL,SHIPS,LSHIP,VARIANTS,CYCLES,SUNITS,
     2 LSUNIT,COMMENTS
      CHARACTER*80 AS,FIS,STHDATAS
      CHARACTER SRUN*6,SHIPTYPS*8,TRIALS*40,SUNITS*6,COMMENTS*40
      CHARACTER SHIPS*5
      CHARACTER VARIANTS*1,CYCLES*2

      COMMON /BLK2/ STHRUN,CNT,COUNT,NSTHCHAN,GRAV,LPP,LCG,DBLWL,
     2 SRATE,DT,TSTART,TSTOP,TRUN,WAVEHT,SURGE,SWAY,HEAVE,ROLL,PITCH,
     2 YAW,STHDATA,WAVEHTP,SHPSPD,HDNG,SEATYPS,SIGWH,TMODAL,STATIS,
     2 STHCHN,STHUNT,STHSTD,ASCII
      INTEGER CNT,COUNT,ASCII
      REAL LPP,LCG
      CHARACTER STHCHN(10)*8,STHUNT(10)*6,SEATYPS*2
      REAL STHSTD(10,2),STHDATA(10),WAVEHTP(3)

      COMMON /WAVEPNT/ NWPOINT,WPTNUM,WPNTXLOC,WPNTYLOC,WPNTZLOC,
     2 WPNTNAMES
      DIMENSION WPTNUM(3),WPNTXLOC(3),WPNTYLOC(3),WPNTZLOC(3)
      CHARACTER WPNTNAMES(3)*20
      INTEGER WPTNUM
```

```
1000  FORMAT (A)
1010  FORMAT (F7.3)
1020  FORMAT (I8)

      FIS = STHDATAS(1:LSTHDATA)//'\SR'//SRUN(KSRUN:LSRUN)//'.TEX'
      OPEN (3,FILE=FIS,FORM='FORMATTED',STATUS='OLD')

   10 CONTINUE

      READ (3,1000,END=50) AS

      IF (AS(18:26) .EQ. 'SHIP TYPE') SHIPTYPS = AS(30:37)

      IF (AS(18:22) .EQ. 'TITLE') THEN
        TRIALS = AS(26:65)
        CALL SLENTH (TRIALS,LTRIAL)
      END IF

      IF (AS(18:29) .EQ. 'HULL VARIANT') VARIANTS = AS(33:33)
      IF (AS(18:29) .EQ. 'SMP CYCLE NO') CYCLES = AS(33:34)

      IF (AS(18:22) .EQ. 'UNITS') THEN
        SUNITS = AS(26:31)
        CALL SLENTH (SUNITS,LSUNIT)
        CALL UCASE (SUNITS,LSUNIT)
      END IF

      IF (AS(18:24) .EQ. 'GRAVITY') THEN
        READ (AS(28:36),1010) GRAV
      ENDIF

      IF (AS(18:28) .EQ. 'SHIP LENGTH') THEN
        READ (AS(32:39),1010) LPP
      ENDIF

      IF (AS(18:29) .EQ. 'LONGITUDINAL') THEN
        READ (AS(65:72),1010) LCG
      ENDIF

      IF (AS(18:25) .EQ. 'DISTANCE') THEN
        READ (AS(56:63),1010) DBLWL
      ENDIF

      IF (AS(18:24) .EQ. 'COMMENT') COMMENTS = AS(28:67)

      IF (AS(18:28) .EQ. 'SAMPLE RATE') THEN
        READ (AS(32:38),1010) SRATE
        DT = 1./SRATE               ! Time between samples in seconds
      ENDIF

      IF (AS(18:27) .EQ. 'START TIME') THEN
        READ (AS(31:38),1010) TSTART
      ENDIF

      IF (AS(18:27) .EQ. 'STOP  TIME') THEN
        READ (AS(31:38),1010) TSTOP
      ENDIF

      IF (AS(18:27) .EQ. 'RUN   TIME') THEN
       READ (AS(31:38),1010) TRUN
```

```
      ENDIF

      IF (AS(18:27) .EQ. 'SHIP SPEED') THEN
        READ (AS(31:35),'(F5.2)') SHPSPD
      END IF

      IF (AS(30:36) .EQ. 'HEADING') THEN
        READ (AS(40:44),'(F5.0)') HDNG
      END IF

      IF (AS(18:25) .EQ. 'SEA TYPE') THEN
        IF (AS(30:31) .EQ. 'LO') SEATYPS = 'LC'
        IF (AS(30:31) .EQ. 'SH') SEATYPS = 'SC'
      END IF

      IF (AS(18:24) .EQ. 'SIGNIF.') THEN
        READ (AS(40:45),'(F6.2)') SIGWH
      END IF

      IF (AS(18:22) .EQ. 'MODAL') THEN
        READ (AS(40:45),'(F6.2)') TMODAL
      END IF

      IF (AS(18:26) .EQ. 'STATISTIC') THEN
        READ (AS(54:59),'(F6.2)') STATIS
      END IF

      IF (AS(18:39) .EQ. 'NUMBER OF WAVE POINTS:') THEN
        READ (AS(40:44),'(I5)')  NWPOINT
        IF (NWPOINT .GT. 3) NWPOINT = 3
        DO 20 I = 1,6
           READ (3,1000)AS
 20     CONTINUE

        IF (NWPOINT .GT. 0) THEN
          DO 30 I = 1,NWPOINT
            READ (3,'(10X,I4,3F8.1,A20)') WPTNUM(I),WPNTXLOC(I),
     2      WPNTYLOC(I),WPNTZLOC(I), WPNTNAMES(I)
 30       CONTINUE
        ENDIF

     ENDIF


      IF (AS(38:48) .EQ. 'STATISTICAL') THEN
        READ (3,'(///)')
        DO 40 I=1,NSTHCHAN
        READ (3,'(7X,A8,2X,A6,10X,F10.3,22X,F10.3)') STHCHN(I),
     2  STHUNT(I),(STHSTD(I,J),J=1,2)
 40     CONTINUE
      END IF

      GO TO 10

 50   CLOSE (3)                       ! Close STH.TEX file

      RETURN
      END


C DECK SLENTH      -  Returns location of last non-blank character in a string
*     3/31/88    8:45 am
```

```
      SUBROUTINE SLENTH (AS,K)

      CHARACTER*(*) AS

      L=LEN(AS)
      K=L+1
      DO 10 M=1,L
      K=K-1
      IF (AS(K:K) .NE. CHAR(32)) GO TO 20   ! Test for trailing blanks
   10 CONTINUE
   20 CONTINUE

      RETURN
      END


C DECK UCASE       -  Converts strings to uppercase
*     4/16/88     11:20 pm

      SUBROUTINE UCASE (AS,L)

      CHARACTER*(*) AS
      CHARACTER*1 LC(26),UC(26)
      DATA LC /'a','b','c','d','e','f','g','h','i','j','k','l','m',
     2 'n','o','p','q','r','s','t','u','v','w','x','y','z'/
      DATA UC /'A','B','C','D','E','F','G','H','I','J','K','L','M',
     2 'N','O','P','Q','R','S','T','U','V','W','X','Y','Z'/

      DO 20 I=1,L
      DO 10 J=1,26
      IF (AS(I:I) .NE. LC(J)) GO TO 10
      AS(I:I) = UC(J)
      GO TO 20
10    CONTINUE
20    CONTINUE

      RETURN
      END


C DECK WRACTHLOG   -  Write ACTHLOG text file
*     9/3/89      8:15 pm

      SUBROUTINE WRACTHLOG (FIS,ACTHDATAS,LACTHDATA,TRIALS,LTRIAL,
     2 RUNNO,TRUN,DTGS,COMMENTS,ASCII)

      CHARACTER*(*) FIS,ACTHDATAS,TRIALS,DTGS,COMMENTS
      INTEGER RUNNO,ASCII
      CHARACTER*80 AS


*-----------------------------------------------------------------
*                  Open ACTHLOG text file

      FIS=ACTHDATAS(1:LACTHDATA)//'\ACTHLOG.TEX'

      OPEN (3,FILE=FIS,STATUS='NEW',ERR=10)

      WRITE (3,"(/27X,'ACTH LOG RUN SUMMARY')")
      WRITE (3,"(/19X,'TRIAL:   ',A)") TRIALS(1:LTRIAL)
      WRITE (3,"(/19X,'ACTH DATA PATH :    ',A)") ACTHDATAS(1:LACTHDATA)
```

```
      WRITE (3,"(//19X,'TYPE CODE :    BI - BINARY,  AS - ASCII')")
      WRITE (3,"(/'  RUN TYPE   TIME    DATE-TIME-GROUP              '
    2 '   COMMENTS')")
      GO TO 20

   10 OPEN (3,FILE=FIS,STATUS='OLD',ERR=99)

   15 READ (3,1000,ERR=20) AS
 1000 FORMAT(A)
      GO TO 15

   20 IF (MOD(RUNNO, 5) .EQ. 1) WRITE (3,*) "    "
      RTIME = TRUN / 60              ! Run time in minutes
      IF (ASCII .EQ. 1) THEN         ! Binary data format
        AS = 'BI'
      ELSE                           ! ASCII data format
        AS = 'AS'
      END IF
      WRITE (3,'(I5,2X,A2,F6.1,A4,3X,A13,4X,A)')
    2 RUNNO, AS(1:2), RTIME, ' MIN', DTGS, COMMENTS(1:40)

      CLOSE (3)                      ! Close ACTHLOG.TEX file

      RETURN

   99 WRITE (*,*) ' ERROR in writing ACTHLOG.TEX file'
      STOP

      END


C DECK WRACTHTEXT  -  Write ACTH text file
*     9/3/89      8:20 pm

      SUBROUTINE WRACTHTEXT

      COMMON /BLK0/ PI,DEGRAD,RADDEG,MONTHS,WAVEHTS,ORGNAMES,
    2 EPTNAMES,SPTNAMES,CHTYPES,CHUNITS,CHSYSTMS
      CHARACTER MONTHS(12)*3,WAVEHTS*12,ORGNAMES(6)*12
      CHARACTER EPTNAMES(7)*12,SPTNAMES(7)*12
      CHARACTER CHTYPES(5)*3,CHUNITS(7)*6,CHSYSTMS(2)*5

      COMMON /BLK1/ AS,FIS,STHDATAS,LSTHDATA,SRUN,KSRUN,LSRUN,
    2 SHIPTYPS,TRIALS,LTRIAL,SHIPS,LSHIP,VARIANTS,CYCLES,SUNITS,
    2 LSUNIT,COMMENTS
      CHARACTER*80 AS,FIS,STHDATAS
      CHARACTER SRUN*6,SHIPTYPS*8,TRIALS*40,SUNITS*6,COMMENTS*40
      CHARACTER SHIPS*5
      CHARACTER VARIANTS*1,CYCLES*2

      COMMON /BLK2/ STHRUN,CNT,COUNT,NSTHCHAN,GRAV,LPP,LCG,DBLWL,
    2 SRATE,DT,TSTART,TSTOP,TRUN,WAVEHT,SURGE,SWAY,HEAVE,ROLL,PITCH,
    2 YAW,STHDATA,WAVEHTP,SHPSPD,HDNG,SEATYPS,SIGWH,TMODAL,STATIS,
    2 STHCHN,STHUNT,STHSTD,ASCII
      INTEGER CNT,COUNT,ASCII
      REAL LPP,LCG
      CHARACTER STHCHN(10)*8,STHUNT(10)*6,SEATYPS*2
      REAL STHSTD(10,2),STHDATA(10),WAVEHTP(3)

      COMMON /BLK3/ ACTHDATAS,LACTHDATA,STARTRUN,NRUNS,ACTHRUN,DTGS,
    2 ARUN,KARUN,LARUN,NPOINT,PNT,PNTXLOC,PNTYLOC,PNTZLOC,PNTNAMES,
    2 NCHMAX,NCHAN,POINTS,SHIPSYS,CHNPTNO,CHNXLOC,CHNYLOC,CHNZLOC,
```

```
     2 CHNPTNA,CTITLE,CTYPE,CUNITS,CSYSTM,CH,CHN,CHNNUM,C1,ACTHDATA,
     2 FACTOR,RESULTS,PEAK
       CHARACTER*80 ACTHDATAS
       CHARACTER ARUN*6,DTGS*13
       INTEGER STARTRUN,ACTHRUN,PNT,POINTS,SHIPSYS
       DIMENSION PNTXLOC(0:10),PNTYLOC(0:10),PNTZLOC(0:10)
       CHARACTER PNTNAMES(0:10)*20
       DIMENSION CHNXLOC(16),CHNYLOC(16),CHNZLOC(16)
       INTEGER CHNPTNO(16)
       CHARACTER*20 CHNPTNA(16)
       CHARACTER*12 CTITLE(16)
       CHARACTER*4 CTYPE(16)
       CHARACTER*4 CUNITS(16)
       CHARACTER*5 CSYSTM(16)
       INTEGER CH(16,5),CHN,CHNNUM
       INTEGER*2 C1(16)
       REAL ACTHDATA(16)
       DIMENSION FACTOR(16),RESULTS(16,4),PEAK(16)

       COMMON /WAVEPNT/ NWPOINT,WPTNUM,WPNTXLOC,WPNTYLOC,WPNTZLOC,
     2 WPNTNAMES
       DIMENSION WPTNUM(3),WPNTXLOC(3),WPNTYLOC(3),WPNTZLOC(3)
       CHARACTER WPNTNAMES(3)*20
       INTEGER WPTNUM


*---------------------------------------------------------------------
*                   Write ARX.TEX file

       FIS = ACTHDATAS(1:LACTHDATA)//'\AR'//ARUN(KARUN:LARUN)//'.TEX'
       OPEN (3,FILE=FIS,FORM='FORMATTED',STATUS='UNKNOWN')

       WRITE (3,'("RUN DATE-TIME-GROUP = ",A13)') DTGS
       WRITE (3,'(/A13,", 0, 0,",I5,", 0, 0,",F5.1,",",I4)')
     2 DTGS,HDNG,SIGWH,TMODAL
       WRITE (3,'(//77("-"))')
       WRITE (3,'(/"TRIAL:  ",A)') TRIALS(1:LTRIAL)
       WRITE (3,'(/"UIC CODE:  ",A5)') SHIPS
       WRITE (3,'(/"RUN:",I4)') ACTHRUN
       WRITE (3,'(/"COMMENTS:  ",A)') COMMENTS(1:40)
       WRITE (3,'(/"CORRESPONDING STH RUN:",I4)') STHRUN
       WRITE (3,'(/"SAMPLE RATE :",F5.1)') SRATE
       WRITE (3,'("START TIME:",F8.1)') TSTART
       WRITE (3,'("STOP  TIME:",F8.1)') TSTOP
       WRITE (3,'("RUN   TIME:",F8.1)') TRUN
       WRITE (3,'(/,"SHIP TYPE: ",A)') SHIPTYPS
       WRITE (3,'("SHIP:  ",A)') SHIPS
       WRITE (3,'("HULL VARIANT:  ",A)') VARIANTS
       WRITE (3,'("SMP CYCLE NO:  ",A)') CYCLES
       WRITE (3,'(/,"UNITS:  ",A)') SUNITS
       WRITE (3,'("GRAVITY:  ",F10.4)') GRAV
       WRITE (3,'("SHIP LENGTH:  ",I4)') LPP
       WRITE (3,400) LCG
 400   FORMAT('LONGITUDINAL CENTER OF GRAVITY (REF FROM FP):  ',F10.2)
       WRITE (3,410) DBLWL
 410   FORMAT('DISTANCE FROM BASELINE TO WATERLINE:  ',F10.2,//)
       WRITE (3,'("SHIP SPEED: ",F5.2," KNOTS")') SHPSPD
       WRITE (3,420) HDNG
 420   FORMAT (/'PREDOMINANT HEADING : ',F5.0,' DEG'/
     2 /3X,' SMP OUTPUT HEADING REF. : '
     2 /3X,'--------------------------'
     2 /3X,'    0 deg=head seas,       '
```

```
   2 /3X,'    90 deg=stbd beam seas,   '
   2 /3X,'   180 deg=following seas    '//)
     IF (SEATYPS(1:2) .EQ. "LC") THEN
       WRITE (3,'("SEA TYPE :  LONGCRESTED  SEAS")')
     ELSE
       WRITE (3,'( "SEA TYPE :  SHORTCRESTED SEAS")')
     END IF
     WRITE (3,430) SIGWH,SUNITS
 430 FORMAT ('SIGNIF. WAVE HEIGHT : ',F6.2,' ',A6)
     WRITE (3,440) THODAL
 440 FORMAT ('MODAL WAVE PERIOD   : ',F6.2,' SEC'/)
     WRITE (3,450) STATIS
 450 FORMAT ('STATISTIC USED FOR ROLL ITERATION : ',F6.2,' * RMS')

     WRITE (3,'(///32X,"STH PROGRAM"/28X,"STATISTICAL RESULTS"//
   2 24X,"TIME DOMAIN   FREQ. DOMAIN"/
   2 " CHAN   NAME     UNIT       STDDEV        STDDEV"/)')
     DO 10 I = 1,NSTHCHAN
     WRITE (3,460) I,STHCHN(I),STHUNT(I),(STHSTD(I,J),J=1,2)
 460 FORMAT (I4,3X,A8,2X,A6,F10.3,4X,F10.3)
  10 CONTINUE

     WRITE (3,470) NWPOINT
 470 FORMAT (///'NO OF WAVE POINTS: ',I3//)

     WRITE (3,480)
 480 FORMAT (28X,'List of Wave Points'//10X,
   2 '  NO    XLOC    YLOC    ZLOC         NAME'/12X,51('-'))
     IF (NWPOINT .GT. 0) THEN
       DO 20 PNT=1,NWPOINT
       WRITE (3,'(10X,I4,3F7.1,3X,A20)') PNT,WPNTXLOC(PNT),
   2   WPNTYLOC(PNT),WPNTZLOC(PNT),WPNTNAMES(PNT)
  20   CONTINUE
     END IF

     WRITE (3,490) NPOINT
 490 FORMAT (///'NO OF POINTS: ',I3//)

     WRITE (3,500)
 500 FORMAT (28X,'List of Points'//10X,
   2 '  NO    XLOC    YLOC    ZLOC         NAME'/12X,51('-'))
     IF (NPOINT .GT. 0) THEN
       DO 30 PNT=1,NPOINT
       WRITE (3,'(10X,I4,3F7.1,3X,A20)') PNT,PNTXLOC(PNT),
   2   PNTYLOC(PNT),PNTZLOC(PNT),PNTNAMES(PNT)
  30   CONTINUE
     END IF

     WRITE (3,505) NCHAN
 505 FORMAT (///'NO OF CHANNELS: ',I3//)

     WRITE (3,510)
 510 FORMAT (19X,'List of Channels with Associated Points'/)
     WRITE (3,520)
 520 FORMAT (13X,'CHANNEL',29X,'POINT')
     WRITE (3,530)
 530 FORMAT (' NO. NAME   TYPE  UNIT  SYSTEM     NO.  XLOC  YLOC'
   2 '  ZLOC      NAME'/1X,29("-"),5X,44("-"))
     DO 40 CHN = 1,NCHAN
     WRITE (3,540) CHN,CTITLE(CHN),CTYPE(CHN),CUNITS(CHN),CSYSTM(CHN),
   2 CHNPTNO(CHN),CHNXLOC(CHN),CHNYLOC(CHN),CHNZLOC(CHN),CHNPTNA(CHN)
 540 FORMAT (I3,2X,A6,2X,A3,2X,A4,2X,A5,6X,I2,2X,F5.2,1X,F5.1,1X,F5.1,
```

```
     2 2X,A20)
  40   CONTINUE

       WRITE (3,'(///)')
       WRITE (3,'(77("-")/"|",22X,"M I N I M U M   A N A L Y S I S",
     2 22X,"|"/77("-")/"| CHAN. TITLE",7X,"UNITS",6X,"MEAN",6X,
     2 "STD. DEV.",5X,"MAX",9X,"MIN",6X,"|"/77("-"))')
       DO 230 CHN=1,NCHAN
       WRITE (3,1010) CHN,CTITLE(CHN),CUNITS(CHN),
     2 (RESULTS(CHN,J),J=1,4)
1010   FORMAT ('|  ',I2,2X,A12,2X,A4,1X,1P4E12.3,'  |')
       IF (CHN.GT.1 .AND. MOD(CHN,5).EQ.0) WRITE (3,'("|",75X,"|")')
 230   CONTINUE
       WRITE (3,'(77("-"))')
       WRITE (3,1020)
1020   FORMAT (//'CHANNEL NO./TITLE',8X,'Peak',11X,'Mean',11X,'STDDEV')
       WRITE (3,*) (CHAR(205),I=1,66)
       DO 240 CHN=1,NCHAN
       WRITE (3,1030) CHN,CTITLE(CHN),PEAK(CHN),
     2 (RESULTS(CHN,J),J=1,2)
1030   FORMAT (1X,I2,2X,A12,7X,1PE10.3,5X,1PE10.3,5X,1PE10.3)
 240   CONTINUE
       WRITE (3,'(/"Total number of data records this run = ",I5)')
     2 COUNT

       CLOSE (3)                         ! Close ACTH text file

       RETURN
       END


*************************************************************************

C PROGRAM END
```

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